FINAL
Work Plan
Groundwater and Surface Water Baseline Monitoring
Red Devil Mine, Alaska

June 2016

Prepared for:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
Anchorage Field Office
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Table of Contents

List of Figures

Figure | **Page**

List of Abbreviations and Acronyms

As_2S_3	Orpiment (arsenic sulfide)
As_4S_4	Realgar (arsenic sulfide)
bgs	below ground surface
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
FS	feasibility study
HgS	Cinnabar (mercury sulfide)
RDM	Red Devil Mine
RI	remedial investigation
Sb_2S_3	Stibnite (antimony sulfide)
TAL	target analyte list
TDS	total dissolved solids

1 Introduction

This Baseline Monitoring Work Plan addresses monitoring of groundwater and surface water at the Red Devil Mine (RDM) site. The RDM consists of an abandoned mercury mine and ore processing facility located on public lands managed by the U.S. Department of the Interior Bureau of Land Management (BLM) in southwest Alaska (see Figure 1-1). The BLM initiated a Remedial Investigation (RI)/Feasibility Study (FS) at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority. An RI was performed by Ecology and Environment, Inc. (E & E) on behalf of the BLM under Delivery Order Number L09PD02160 and General Services Administration Contract Number GS-10F-0160J. The RI was performed following the Remedial Investigation/Feasibility Study Work Plan (E & E 2011). Results of the RI are presented in the Final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014). Results of the FS are presented in the Final Feasibility Study, Red Devil Mine, Alaska (E & E 2016a).

Historical mining activities at the RDM included underground and surface mining. Ore processing included crushing, retorting/furnacing, milling, and flotation. Historical mining operations left tailings and other remnants that have affected local soil, surface water, sediment, and groundwater. The final RI report provides detailed background information on the RDM and information on the regulatory framework for the RI/FS. That detailed information is not repeated in this Work Plan.

Data collected during the RI were used to define the site's physical setting, the nature and extent of contamination, and the fate and transport of contaminants. The RI results were used to assess risk to human health and the environment due to exposure to site contaminants. Data gaps associated with groundwater and surface water are being addressed as part of an ongoing RI Supplement. E & E is performing the RI Supplement on behalf of the BLM under Delivery Order Number L14PB00938 and BLM National Environmental Services Blanket Purchase Agreement Number L14PA00149. The RI Supplement is being performed per applicable CERCLA statutes, regulations, and guidance following the Final Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2015).

The BLM initiated baseline groundwater and surface water monitoring in 2012 to augment the RI results and identify seasonal and annual trends in flow, contaminant concentrations, and loading. The 2012 baseline monitoring was performed following the Baseline Monitoring Work Plan (E & E 2012), which is generally consistent with the Red Devil Mine Remedial Investigation/Feasibility Study Work Plan (E & E 2011). Through analysis of 2011 data, it was determined that some key data gaps had yet to be adequately addressed, and the overall RI effort was extended. Thus, the 2012 baseline data were appended to the RI report. Those data were incorporated into the ongoing RI Supplement.

A second round of baseline monitoring of groundwater and surface water was performed in the spring and fall 2015. The 2015 baseline monitoring was performed in conjunction with additional groundwater characterization conducted as part of the RI Supplement. The 2015 groundwater characterization and baseline monitoring were performed using methods described in the Final Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2015). Results of the 2015 groundwater characterization and baseline monitoring are presented in the Draft 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2016b).

1.1 Purpose and Objectives

The purpose of baseline monitoring is to augment the RI results to characterize pre-remedial action conditions at the RDM site. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM. Specific objectives of the baseline monitoring are to:

- Characterize the seasonal variability in groundwater and surface water hydrology and chemistry;
- Characterize the long-term (multiple year) variability in groundwater and surface water hydrology and chemistry; and
- Characterize trends in groundwater and surface water hydrology and chemistry.

This Work Plan establishes procedures for baseline monitoring of groundwater and surface water at the RDM site. It includes a Field Sampling Plan and Quality Assurance Project Plan, provided as Appendices A and B. E & E prepared this Work Plan on behalf of the BLM under Delivery Order Number L14PB00938 and BLM National Environmental Services Blanket Purchase Agreement Number L14PA00149.

This Work Plan was developed to address baseline groundwater and surface water monitoring needs as the BLM understands them at this time. As additional baseline data are gathered, the resulting data will be reviewed and, if appropriate, the approach for subsequent monitoring will be modified to address any data gaps that may be identified or to streamline the monitoring approach.

1.2 Document Organization

The Work Plan is organized into the following chapters.

Chapter 1, Introduction – Describes the purpose and objectives of the baseline monitoring.

Chapter 2, Site Background and Setting – Summarizes the project's location, regional setting, and operational history.

Chapter 3, Data Quality Objectives – Presents results of the data quality objectives process, including identification of the study questions and a description of how they will be addressed through baseline monitoring.

Chapter 4, Overview of Baseline Monitoring Design – Summarizes the design of baseline monitoring based upon results of the RI and previous baseline monitoring.

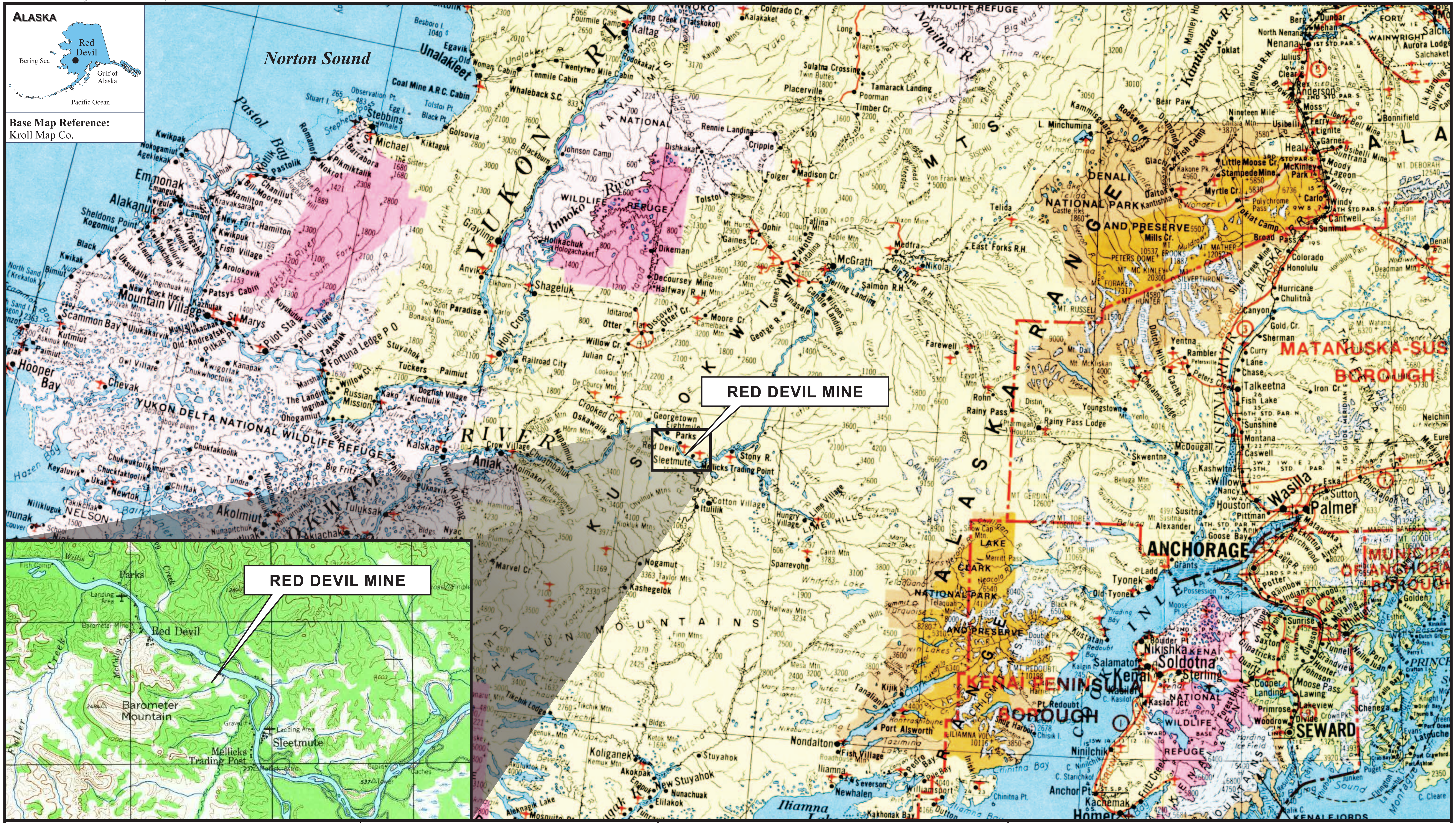
Chapter 5, References – Lists the guidance documents and literature resources cited in this document.

<u>Appendices</u>

A Field Sampling Plan

B Quality Assurance Project Plan

02:EE-001096-0070-08\Figure 1-1 Site Location Map.ai-01/25/13-GRA



ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

N

0 40 80
Approximate Scale in Miles

RED DEVIL MINE
Red Devil, Alaska

Figure 1-1
SITE LOCATION MAP

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2 Site Background and Setting

Existing data and information regarding the RDM are presented in the final RI report. Site background and setting are briefly described in the sections below.

2.1 Project Location and Setting

The RDM site is approximately 250 air miles and 1,500 marine/river barge miles west of Anchorage, Alaska (see Figure 1-1). Located on the southwest bank of the Kuskokwim River approximately 2 miles southeast of the village of Red Devil, the site is 75 air miles northeast of Aniak, the largest village in the region, and approximately 8 miles northwest of the village of Sleetmute. Approximately 15 villages are located downstream of Red Devil on the Kuskokwim River. The RDM site is in a remote location and may be accessed by boat or barge on the Kuskokwim River or by means of an airstrip at the nearby village of Red Devil. An unimproved road leads from the airstrip through the village of Red Devil and to the RDM site.

Figure 2-1 illustrates the upland area encompassed by the RI and RI Supplement and the major features identified above based on aerial photographs taken in 2010 (Aero-Metric, Inc. 2010a) and 2001 (Aero-Metric, Inc. 2010b).

2.2 Operational History

The RDM is an abandoned mercury mine. This section summarizes the history of the RDM; a detailed operational and mining history is available in the RI Report (E & E 2014). The ore minerals at the RDM consisted of cinnabar (mercury sulfide [HgS]), the primary mercury ore mineral, and stibnite (antimony sulfide [Sb_2S_3]). Some realgar (arsenic sulfide [As_4S_4]), orpiment (arsenic sulfide [As_2S_3]), and secondary antimony minerals were locally associated with these ore minerals.

The first claim at the RDM site was staked in 1939 by Hans Halverson. By 1941, underground and surface mining had commenced on a small scale, and the mining was being conducted by the New Idria Quicksilver Mining Company. Processing during this period was conducted first with a Johnson-Mackay retort and then with a 40-ton rotary kiln (Wright and Rutledge 1947). Underground mining expanded between 1941 and 1946, but the market value of mercury dropped twice during this time, forcing operational pauses and several turnovers, ultimately followed by a cessation of mining in 1946 (Webber et al. 1947). In 1952, the DeCoursey Mountain Mining Company leased the mine and resumed operations. In 1954, a large fire rendered the existing mining surface structures unusable.

Following the fire, DeCoursey Mountain Mining Company moved ore processing from the northwest side of Red Devil Creek to the southwest side. Significant investments were made into expanding the production of the mine, with the installation of a larger processing plant with a modified Herreshoff furnace, an airfield, a company village and facilities, a power station, and, a few years later, a reservoir (Malone 1962). By 1963, there were 9,600 feet of underground mine workings. Mining slowed again in 1963, and the mine shut down again in 1965.

In 1969, the mine was dewatered and operations resumed under Alaska Mines and Minerals, Inc. A new area of surface mining along the ore zone northwest of Red Devil Creek was created during this time (Buntzen and Miller 2004). Due to complications in separating the mercury compounds from antimony compounds, a flotation mill and tailing ponds were installed around this time to help produce cinnabar and stibnite concentrates (TNH 1987). Mercury and antimony prices fell sharply in 1971, and the mine again ceased operations in June of that year. Dewatering operations continued for 11 years with the expectation that prices would rebound and the mine would reopen; however, prices remained stagnant and the mine was permanently closed in 1982 (MACTEC 2005).

Locations of monitoring wells, including wells installed during the RI, pre-RI wells, and wells installed as part of the 2015 RI Supplement, are illustrated in Figure 2-2. Also shown on Figure 2-2 are the locations of the surface water monitoring stations established for the 2015 surface water monitoring.

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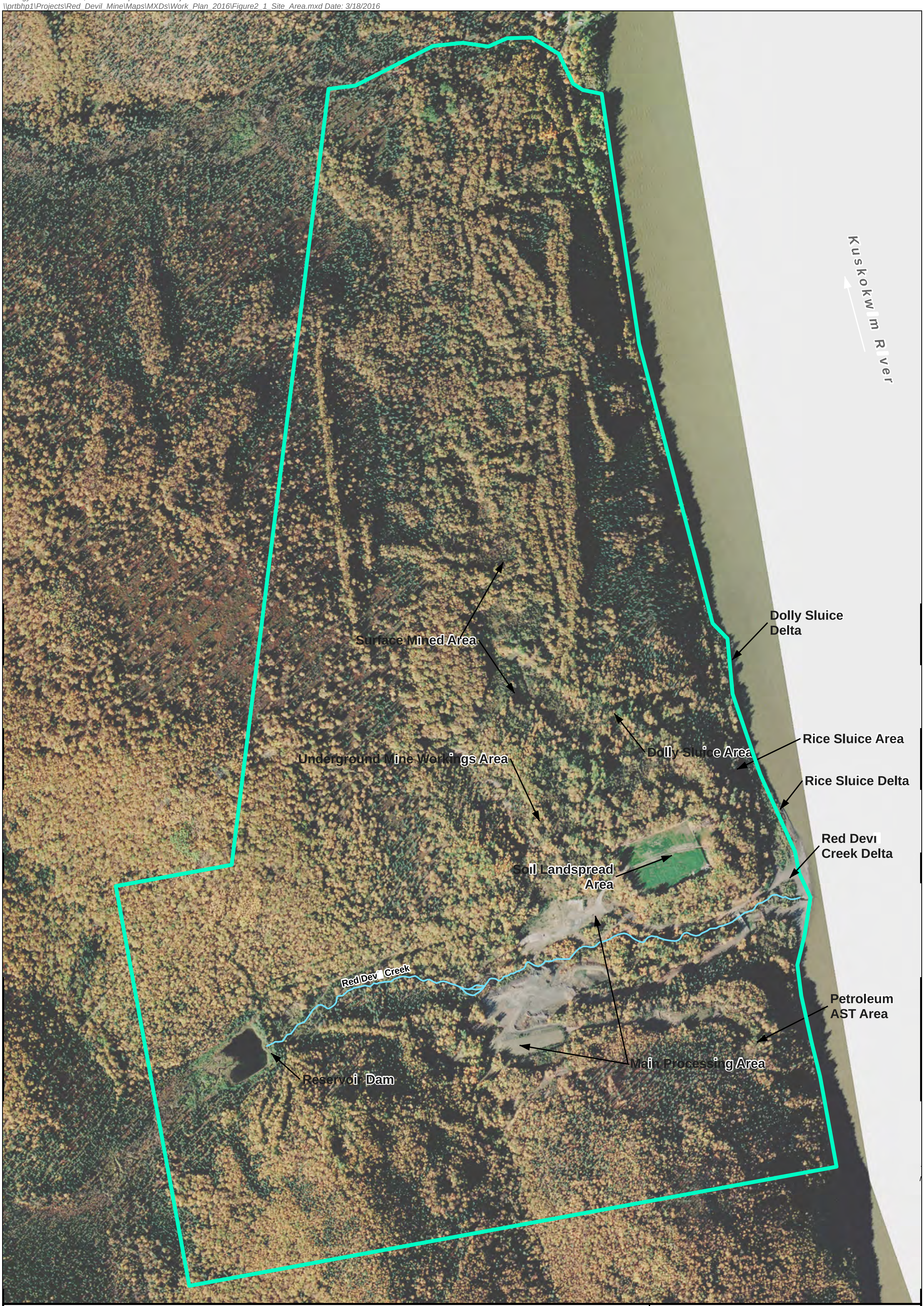

Upland Area Encompassed by Remedial Investigation

RED DEVIL MINE

Red Devil, Alaska

Figure 2-1
Upland Area Encompassed by Remedial Investigation

0 75 150 300 450 600 750 Feet
0 37.5 75 150 225 Meters
Scale 1:4,562

Digitial aerial orthophotograph taken on September 21, 2010 (AeroMetric 2010)

Ecology & Environment, Inc. GIS Department Project:
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Baseline Monitoring Locations

- 2015 RI Supplement Monitoring Well
- Existing Monitoring Well
- Surface Water
- 2014 5-foot Contour
- 2014 1-foot Contour
- Area of 2014 NTCRA Re-grading
- 2010 5-foot Contour
- Post-NTCRA Stream Alignment
- Red Devil Creek
- Settling Pond
- Monofill
- Historical Structure
- Approximate Location of Proposed Repository Footprint
- Seep Location

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)

Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)

RED DEVIL MINE

Red Devil, Alaska

Figure 2-2
Groundwater and Surface Water Baseline Monitoring Locations

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100 125
Meters
Scale 1:2,500

3 Data Quality Objectives

The data quality objectives (DQO) process specifies project decisions, the data quality required to support those decisions, specific data types needed, and data collection requirements. It also ensures that the analytical techniques used will generate the specified data quality (EPA 2000) and that the resources required to generate the data are justified. The DQO process consists of seven steps. The output from each step influences the choices that will be made later in the process.

The DQO steps are as follows.

1. State the problem.
2. Identify the decision.
3. Identify the inputs to the decision.
4. Define the study boundaries.
5. Develop a decision rule.
6. Specify tolerable limits on decision errors.
7. Optimize the design.

During the first six steps of the process, the planning team develops decision performance criteria (that is, the DQOs) that will be used to develop the data collection design. The final step involves refining the data collection design based on the DQOs. A discussion of these steps and their application to the planned groundwater and surface water baseline monitoring is provided below.

3.1 Step 1: State the Problem

The key problem statements for groundwater and surface water monitoring are presented below.

Groundwater

Additional multi-year baseline monitoring of groundwater conditions, including depth, hydraulic gradient, and concentrations of inorganic elements and organic compounds, is needed to further augment the RI results and identify temporal (e.g., seasonal and annual) variability and trends in groundwater and surface water hydrology and contaminant concentrations.

Surface Water
Additional multi-year baseline monitoring of surface water conditions (including flow rates and concentrations and loading of inorganic elements) is needed to further augment the RI results and identify temporal (e.g., seasonal and annual) variability and trends in groundwater and surface water hydrology and contaminant concentrations

3.2 Step 2: Identify the Decision
The key study questions (data gaps) for the groundwater and surface water baseline monitoring are described below.

Groundwater
The baseline groundwater monitoring addresses the following study question: What are the temporal (e.g., seasonal and annual) variability and trends of groundwater conditions (including depth, hydraulic gradient, and concentrations of inorganic elements and organic compounds) at the site?

Surface Water
The baseline surface water monitoring addresses the following study question: What are the temporal (e.g., seasonal and annual) variability and trends of surface water conditions (including flow rates and concentrations and loading of inorganic elements) at the site?

3.3 Step 3: Identify the Inputs to the Decision
This section identifies the types of information needed to support resolution of the decisions. The specific types of information needed to address the decisions for groundwater and surface water are presented below.

Groundwater
To address the lack of information on the temporal variability (e.g., seasonal and annual) of groundwater conditions at the site, the following types of additional baseline groundwater monitoring data will be needed:

1) Information on groundwater depth to be collected during static water level measurements in existing wells at the site.
2) Information on groundwater quality to be obtained by sampling groundwater from selected existing monitoring wells at the site. Groundwater quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total target analyte list (TAL) metals and mercury; total and dissolved low-level mercury; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).
3) Information on groundwater quality to be obtained by analyzing samples from selected wells for semivolatile organic compounds, diesel range

organics, gasoline range organics, and benzene, toluene, ethylbenzene, xylenes.

Surface Water

To address the lack of information on the temporal variability (e.g., seasonal and annual) of surface water conditions at the site, the following types of additional baseline surface water monitoring data will be needed:

1) Information on surface water discharge at selected locations along Red Devil Creek.
2) Information on surface water quality at locations along Red Devil Creek. Surface water quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved TAL metals and mercury; total organic carbon; total suspended solids; total dissolved solids; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).

3.4 Step 4: Define the Study Boundaries

The baseline monitoring activities will be performed within the upland area of the site (as shown on Figure 2-1). Planned sampling locations are presented in Chapter 4.

3.5 Step 5: Develop a Decision Rule

It is anticipated that data collected as part of the baseline monitoring activities will be used to support the development of site-wide remedial decisions at the RDM site.

3.6 Step 6: Specify Tolerable Limits on Decision Errors

This step specifies tolerable limits on decision errors, which are established performance goals for the data collection design. Because analytical data and other measurements can only estimate true values, decisions that are based on measurement data could be in error. These errors are as follows.

1. Concentrations may vary over time and space. Limited sampling may miss some features of this natural variation because it is usually impossible or impractical to measure every point of a population. Sampling design errors occur when the sampling design is unable to capture the complete extent of natural variability that exists in the true state of the environment.
2. Analytical methods and instruments are never perfect; hence, a measurement can only estimate the true value of an environmental sample. Measurement error refers to a combination of random and systematic errors that inevitably arise during the measurement process.

A sufficient number of samples will be collected to minimize the risks of decision errors. Decision errors also will be minimized through the appropriate selection of sample locations.

Quality control samples will be collected and analyzed with environmental samples to ensure that data are of known precision and accuracy. Control limits on both precision and accuracy for groundwater and surface water samples for planned analyses are addressed in the Quality Assurance Project Plan, provided as Appendix B.

3.7 Step 7: Optimize the Design for Obtaining Data

Data gaps pertaining to the temporal (e.g., seasonal and annual) variability and trends in groundwater and surface water hydrologic and chemical characteristics are identified in Section 3.2. Based on these data gaps and Steps 1 through 6 of this DQO process, a study design for the baseline monitoring has been developed. Details of the study design are presented in Chapter 4 of this Work Plan.

4 Overview of Baseline Monitoring Design

Historical mining operations left tailings and other remnants that have affected local soil, surface water, sediment, and groundwater. Based on the locations of tailings and other features, baseline monitoring is focused on the following areas:

- The Main Processing Area.
- Red Devil Creek, extending from a reservoir upstream of the Main Processing Area to the creek's delta at its confluence with the Kuskokwim River.
- The area west of the Main Processing Area where historical surface exploration and mining occurred, referred to as the Surface Mined Area. The Surface Mined Area is underlain by the area of underground mine workings. The "Dolly Sluice" and "Rice Sluice" and their respective deltas on the bank of the Kuskokwim River are associated with the Surface Mined Area.

Figure 2-1 illustrates the upland area encompassed by the RI and RI Supplement and the major features identified above.

The Main Processing Area contains most of the former site structures and is where ore beneficiation and mineral processing were conducted. The area is split by Red Devil Creek. Underground mine openings (shafts, adits, and stopes to the surface) and ore processing and mine support facilities (housing, warehousing, and so forth) were located on the west side of Red Devil Creek until 1955. After 1955, all ore processing was conducted at structures and facilities on the east side of Red Devil Creek. The Main Processing Area includes three monofills. The monofills are essentially landfills that contain demolished mine structure debris and other material. Two of the monofills, #1 and #3, are unlined. Monofill #2, on the east side of Red Devil Creek, is an engineered and lined containment structure for building debris and materials from the demolished Post-1955 Retort structure.

The study design presented in this document addresses these needs and was developed following the DQO planning process presented in Chapter 3. An overview of the study design is presented in this chapter. Detailed field investigation locations, objectives, rationale, methodologies, and procedures are provided in the Field Sampling Plan, provided as Appendix A of this Work Plan.

4.1 Groundwater

Additional groundwater characterization will be performed to gather the types of additional information identified in Section 3.3. Additional groundwater characterization will include collecting groundwater data from selected existing monitoring wells. Groundwater monitoring will be performed using existing RI monitoring wells and wells installed as part of the RI Supplement in 2015.

It is anticipated that one round of groundwater monitoring of the wells will be performed in the spring and a second in the fall.

Static water levels will be measured in all existing monitoring wells. Selected existing monitoring wells will be sampled for field and laboratory water quality parameters. Locations of monitoring wells planned for monitoring, objectives, rationale, methodologies, and procedures for monitoring well installation and monitoring are provided in the Field Sampling Plan.

Data generated during the planned baseline monitoring will be presented in a baseline monitoring report. Any trends in groundwater elevation and surface water discharge, groundwater, and surface water contaminant concentrations (for arsenic, mercury, and antimony), and surface water contaminant loading, will be identified. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM. As noted in Section 1, this Work Plan was developed to address baseline groundwater and surface water monitoring needs as the BLM understands them at this time. As additional baseline data are gathered, the resulting data will be reviewed to identify any possible data gaps or appropriate areas to streamline the subsequent monitoring approach. Results of this review will be summarized in the baseline monitoring report.

4.2 Surface Water

Additional surface water characterization will be performed to gather the types of additional information identified in Section 3.3. Additional surface water characterization will be performed at eight surface water monitoring stations, including the seep, along Red Devil Creek.

At the selected surface water monitoring locations along Red Devil Creek and the seep, discharge rates will be measured and surface water will be sampled for field and laboratory water quality parameters. Locations of planned surface water monitoring stations, objectives, rationale, methodologies, and procedures for surface water characterization and monitoring are provided in the Field Sampling Plan.

It is anticipated that one round of surface water monitoring will be performed in the spring and a second in the fall.

Data generated during the planned baseline monitoring will be presented in a baseline monitoring report. Any trends in groundwater elevation and surface water discharge, groundwater, and surface water contaminant concentrations (for arsenic, mercury, and antimony) and surface water contaminant loading will be identified. As noted in Section 1, this Work Plan was developed to address baseline groundwater and surface water monitoring needs as the BLM understands them at this time. As additional baseline data are gathered, the resulting data will be reviewed to identify any possible data gaps or appropriate areas to streamline the subsequent monitoring approach. Results of this review will be summarized in the baseline monitoring report.

5 References

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A Field Sampling Plan

FINAL
Field Sampling Plan for Groundwater and Surface Water Baseline Monitoring

Red Devil Mine, Alaska

June 2016

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Table of Contents

Section Page

Table of Contents (cont.)

Section **Page**

List of Tables

Table **Page**

List of Figures

Figure **Page**

List of Abbreviations and Acronyms

°C	degree Celsius
ASTM	ASTM International (formerly the American Society of Testing and Materials)
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COC	chain-of-custody
DOT	U.S. Department of Transportation
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FSP	Field Sampling Plan
GPS	Global Positioning System
IATA	International Air Transportation Association
IDW	investigation-derived waste
MS	matrix spike
MSD	matrix spike duplicate
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDM	Red Devil Mine
RI	remedial investigation
SOP	standard operating procedure
TAL	target analyte list
USGS	U.S. Geological Survey
Work Plan	Red Devil Mine Baseline Monitoring Work Plan

1 Introduction

This document is a Field Sampling Plan (FSP) to be used for baseline groundwater and surface water monitoring to be conducted at the Red Devil Mine (RDM) site in Red Devil, Alaska. The FSP is to be used in conjunction with the Baseline Monitoring Work Plan (Work Plan) and the Quality Assurance Project Plan (QAPP), which is provided as Appendix B to the Work Plan. Collectively, these documents address monitoring of groundwater and surface water at the RDM site.

The RDM consists of an abandoned mercury mine and ore processing facility located on public lands managed by the U.S. Department of the Interior Bureau of Land Management (BLM) in southwest Alaska (see Work Plan Figure 1-1). The BLM initiated a Remedial Investigation (RI)/Feasibility Study (FS) at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority. An RI was performed by Ecology and Environment, Inc., (E & E) on behalf of the BLM under Delivery Order Number L09PD02160 and General Services Administration Contract Number GS-10F-0160J. The RI was performed following the Remedial Investigation/Feasibility Study Work Plan (E & E 2011). Results of the RI are presented in the Final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014). Results of the FS are presented in the Final Feasibility Study, Red Devil Mine, Alaska (E & E 2016a).

Data collected during the RI were used to define the site's physical setting, the nature and extent of contamination, and the fate and transport of contaminants. The RI results were used to assess risk to human health and the environment due to exposure to site contaminants. The FS addresses contaminated tailings/waste rock, soil, and Red Devil Creek sediments. It does not address remedies for groundwater or Kuskokwim River sediments because the need for, and extent of, cleanup of site groundwater and sediments in the Kuskokwim River has not yet been completely assessed.

Data gaps associated with soil, groundwater, and Kuskokwim River sediments that were identified as part of the development of site-wide remedial alternatives during the preparation of the FS are being addressed as part of an ongoing RI Supplement. E & E is performing the RI Supplement on behalf of the BLM under Delivery Order Number L14PB00938 and BLM National Environmental Services

Blanket Purchase Agreement Number L14PA00149. The RI Supplement is being performed per applicable CERCLA statutes, regulations, and guidance following the Final Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2015).

The BLM initiated baseline groundwater and surface water monitoring in 2012 to augment the RI results and identify seasonal and annual trends in flow, contaminant concentrations, and loading. The 2012 baseline monitoring was performed following the Baseline Monitoring Work Plan (E & E 2012), which is generally consistent with the Red Devil Mine Remedial Investigation/Feasibility Study Work Plan (E & E 2011). Through analysis of 2011 data, it was determined that some key data gaps had yet to be adequately addressed, and the overall RI effort was extended. Thus, the 2012 baseline data were appended to the RI report. Those data were incorporated into the ongoing RI Supplement.

A second round of baseline monitoring of groundwater and surface water was performed in the spring and fall 2015. The 2015 baseline monitoring was performed in conjunction with additional groundwater characterization conducted as part of the RI Supplement. The 2015 groundwater characterization and baseline monitoring were performed using methods described in the Final Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2015). Results of the 2015 groundwater characterization and baseline monitoring are presented in the Draft 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2016b).

The purpose of baseline monitoring is to augment the RI results to characterize pre-remedial action conditions at the RDM site. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM. Specific objectives of the baseline monitoring are to:

- Characterize the seasonal variability in groundwater and surface water hydrology and chemistry;
- Characterize the long-term (multiple year) variability in groundwater and surface water hydrology and chemistry; and
- Characterize trends in groundwater and surface water hydrology and chemistry.

The Work Plan was developed to address baseline groundwater and surface water monitoring needs as the BLM understands them at this time. As additional baseline data are gathered, the resulting data will be reviewed and, if appropriate, the approach for subsequent monitoring will be modified to address any data gaps that may be identified or to streamline the monitoring approach.

The Work Plan summarizes the site setting, site history, and baseline monitoring design. Detailed information for the site setting, site history, and previous investigations is presented in the Final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014).

The purpose of this FSP is to provide specific methodology for the sampling and analysis at the RDM site. It is intended to be used in conjunction with the Work Plan and to be used as a streamlined guide for the field investigation team.

2 Monitoring Locations, Sample Types, and Rationale

This chapter describes the study design for each component of the planned baseline monitoring at the RDM site. The study area for baseline monitoring includes the area encompassed by the RDM monitoring wells and Red Devil Creek from the reservoir dam to its mouth at the Kuskokwim River (see Work Plan Figure 2-1). Selection of locations for surface water monitoring and the selection of monitoring wells to sample were based on data and analyses from the RI and previous baseline monitoring. Surface water and groundwater monitoring locations were chosen based on their potential to express spatially variable trend information and their applicability to a network that spans the full dimensions of the baseline monitoring study area.

The following sections summarize the sample locations, types, and rationale for the planned groundwater and surface water monitoring.

2.1 Groundwater

Baseline groundwater monitoring will be performed to gather the types of information identified in Section 3.3 of the Work Plan. Groundwater monitoring will include collecting groundwater data from existing monitoring wells and will be performed using a combination of field data collection and the results of laboratory analysis for selected analytical parameters as described below. Locations of existing monitoring wells are described in Table 2-1 and shown on Figure 2-1. Information on well construction and previous water level measurements in existing wells is presented in Table 2-2.

At the beginning of each groundwater monitoring event, a round of static water level measurement will be conducted at all existing wells. Following the completion of groundwater sampling near the end of the sampling event, another round of static water level gauging will be conducted at all existing monitoring wells.

Groundwater samples will be collected from the selected monitoring wells identified in Table 2-1. All groundwater samples will be collected for field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total target analyte list (TAL) metals; total low-level mercury; dissolved low-level mercury; total suspended solids; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate). In addition, samples from selected wells will be analyzed for semivolatile organic compounds, diesel range organics, gasoline range organics, and benzene, toluene, ethylbenzene, xylenes. Table 2-1 identifies the wells selected for sampling and the selected laboratory analyses.

2.2 Surface Water

Baseline surface water monitoring will be performed to gather the types of additional information identified in Section 3.3 of the Work Plan. Surface water monitoring will include collecting data from existing surface water monitoring stations and will be performed using a combination of field data collection and the results of laboratory analysis for selected analytical parameters as described below. Locations of existing surface water monitoring stations are described in Table 2-3 and shown on Figure 2-1.

Discharge rate will be measured at each of the selected surface water monitoring locations along Red Devil Creek and the seep.

At the selected surface water monitoring locations along Red Devil Creek and the seep, surface water will be sampled for field and laboratory water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and low-level mercury; dissolved TAL metals and low-level mercury; total organic carbon; total suspended solids; total dissolved solids; inorganic ions (chloride, fluoride, and sulfate); alkalinity (as carbonate/bicarbonate); and nitrate-nitrite as N. Table 2-3 identifies the surface water monitoring stations selected for sampling and the selected laboratory analyses.

A visual survey will be conducted at the site to determine whether additional springs or seeps are present. Surface water samples will be collected and discharge will be measured at any new springs identified during the sampling events.

It is anticipated that the creek will be shallow at most sample locations. To the extent feasible, surface water samples will be collected from mid-depth water in the creek. Specific sampling methodologies are summarized in Chapter 4 of this FSP.

2.3 Quality Control Samples

Following the requirements specified in the QAPP (Appendix B), field quality control (QC) samples will be collected for all matrices and analytes. QC samples will be:

- **Field Duplicates**: A field duplicate sample is a second sample collected at the same time and location as the original sample. Field duplicate samples are collected simultaneously (an extra volume of one sample, which is then homogenized and split into equal aliquots) or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Duplicate sample results are used to assess precision of the overall sample collection and analysis process. For groundwater and surface water, field duplicate samples will be collected at a minimum frequency of one field duplicate for every 10 regular samples for each matrix and sampling method and/or type of equipment used.

- **Matrix Spike**: Matrix spikes (MSs) are used to assess the effect of the sample matrix on analyte recovery. An MS consists of an aliquot of a field sample to which the laboratory adds a known concentration of the analyte(s) of interest. An unspiked aliquot is also analyzed, and the percent recovery for the spiked sample is calculated. Analysis of MSs requires collection of a sufficient volume of sample to accommodate the number of aliquots to be analyzed. The sample(s) chosen for MSs should be representative of the sample matrix but should not contain excessive concentrations of analytes or interfering substances. MSs are analyzed at a frequency of one MS per 20 or fewer samples for each matrix and each sampling event.

- **Rinsate Blanks:** Rinsate blanks are used to assess the effectiveness of equipment decontamination procedures when non-dedicated sampling equipment is used. A rinsate blank is a sample of ASTM Type II reagent grade water or equivalent (i.e., deionized), poured into or over the sampling device or pumped through it, collected in a sample container, and transported to the laboratory for analysis. Rinsate blanks will be collected immediately after the equipment has been decontaminated. The blank will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. A minimum frequency of one rinsate blank per 20 field samples is required for each collection/ decontamination method, by matrix and by sample type.

- **Equipment Blanks**: Equipment blanks are used to demonstrate that dedicated sampling equipment is adequately clean if a certificate is not available to demonstrate cleanliness. Equipment blanks will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. One equipment blank sample for dedicated equipment will be collected at a rate of one for each set of dedicated equipment (i.e., bailers and sample tubing) of identical manufacturer’s lot number.

- **Field Blanks**: Field blanks are laboratory-provided, mercury-free water samples that are processed and treated as a regular sample in all respects, including contact with sampling devices, equipment, sampling site conditions, and analytical procedures. Field blanks are used to determine whether mercury detected in a sample is from the site or can be attributed to contamination. Field blanks will be collected at a rate of one field blank for every 10 regular samples to be analyzed for low-level mercury.

Baseline Monitoring Locations

- 2015 RI Supplement Monitoring Well
- Existing Monitoring Well
- Surface Water
- 2014 5-foot Contour
- 2014 1-foot Contour
- Area of 2014 NTCRA Re-grading
- 2010 5-foot Contour
- Post-NTCRA Stream Alignment
- Red Devil Creek
- Settling Pond
- Monofill
- Historical Structure
- Approximate Location of Proposed Repository Footprint
- Seep Location

RED DEVIL MINE

Red Devil, Alaska

Figure 2-1
Groundwater and Surface Water Baseline Monitoring Locations

Feet: 0 50 100 200 300 400
Meters: 0 12.5 25 50 75 100 125
Scale 1:2,500

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)

Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)

Table 2-1 Groundwater Sample Collection

Monitoring Well ID	General Geographic Area	Location Description	Sample Analyses and Methods										
			Total TAL Metals plus Mercury	Total Low-Level Hg	Dissolved Low Level Hg	Total Suspended Solids	Inorganic Ions	Carbonate Alkalinity as CaCO3	Nitrate Nitrite as N	SVOCs	BTEX (VOCs)	GRO	DRO
			EPA 6010B/6020A /7470A	EPA 1631E	EPA 1631E	SM 2540D	MCAWW 300.0	SM 2320B	MCAWW 353.2	SW846 8021B /8270D	SW846 8260C	AK101	AK102
MW09	Post-1955 Main Processing Area	Downgradient of Monofill #2	X	X	X	X	X	X	X				
MW10		Downgradient from Monofill #2 / Post-1955 Retort Building	X	X	X	X	X	X	X				
MW01		Gravel Pad / Downgradient from Monofill #3	X	X	X	X	X	X	X				
MW16		Shallow/deep well pair / Tailings Area	X	X	X	X	X	X	X				
MW17			X	X	X	X	X	X	X				
MW22		Berm / Downgradient of Settling Pond #3	X	X	X	X	X	X	X	X	X	X	X
MW26	Pre-1955 Main Processing Area	Pre-1955 Main Processing Area	X	X	X	X	X	X	X				
MW27		Shallow/deep well pair near seep on bank of Red Devil Creek / Downgradient of former mine openings / Tailings Area	X	X	X	X	X	X	X				
MW28			X	X	X	X	X	X	X				
MW06		Downgradient of Pre-1955 Retort Area	X	X	X	X	X	X	X				
MW32	Red Devil Creek Downstream Alluvial Area and Delta	Red Devil Creek Downstream Alluvial Area and Delta	X	X	X	X	X	X	X				
MW33			X	X	X	X	X	X	X				
MW39	Surface Mined Area	Northeast of Dolly Shaft and south and assumed downgradient of proposed repository location. Well installed.	X	X	X	X	X	X	X				
MW40		Near 507 Crosscut and Dolly No. 7 / 1280 Crosscut. Well installed.	X	X	X	X	X	X	X				
MW42		Near 325 Adit and 150 Level / 200 Level. Well installed.	X	X	X	X	X	X	X				
MW43		Near 33 Level. Well installed.	X	X	X	X	X	X	X				
MW29		Upgradient from Pre-1955 Main Processing Area	X	X	X	X	X	X	X				
MW30		Upgradient from Pre-1955 Main Processing Area	X	X	X	X	X	X	X				
MW08	Upgradient of Post-1955 Main Processing Area	Upgradient of Post-1955 Main Processing Area	X	X	X	X	X	X	X				
MW19		Upgradient of Settling Ponds #2 and #3	X	X	X	X	X	X	X	X	X	X	X
MW31	Upland Area West of Surface Mined Area	Upland Area West of Surface Mined Area	X	X	X	X	X	X	X				

Key:
BTEX = Benzene, toluene, ethylbenzene, and xylenes
DRO = Diesel range organics
EPA = Environmental Protection Agency
GRO =Gasoline range organics
Hg = Mercury
MCAWW = Methods for Chemical Analysis of Water and Wastes
SVOCs = Semivolatile organic compounds
TAL = Target Analyte List
VOCs = Volatile organic compounds

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		21.72	8/14/2000	NR	235.79
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.87	9/5/2007	13:15	237.64
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		22.16	9/18/2008	13:28	235.35
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.62	6/19/2009	NR	237.89
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		22.27	10/6/2009	17:30	235.24
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		20.04	9/20/2010	18:18	237.47
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.46	8/24/2011	16:38	238.05
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.55	9/1/2011	16:03	237.96
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		17.56	5/26/2012	14:32	239.95
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		18.62	9/9/2012	17:05	238.89
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.43	6/17/2015	13:03	238.08
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		20.80	8/12/2015	12:15	236.71
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		21.03	9/2/2015	9:50	236.48
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD	29.82	20.36	9/10/2015	NR	237.15
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.28	8/14/2000	NR	208.49
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		20.68	9/5/2007	14:40	210.09
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.57	9/18/2008	14:11	208.20
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.51	6/19/2009	NR	211.26
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		23.01	10/7/2009	13:20	207.76
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		20.95	9/20/2010	19:50	209.82
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.44	8/26/2011	10:18	211.33
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.96	9/1/2011	15:41	210.81
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		15.47	5/26/2012	15:17	215.30
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		17.24	9/9/2012	17:10	213.53
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.74	6/17/2015	10:54	211.03
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		21.83	8/12/2015	12:33	208.94
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.20	9/2/2015	9:45	208.57
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD	27.98	21.92	9/10/2015	NR	208.85
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		27.77	8/14/2000	NR	214.35
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.78	9/5/2007	12:25	215.34
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.82	9/18/2008	12:32	215.30
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.43	6/19/2009	NR	216.69
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		27.77	10/6/2009	18:55	214.35
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.79	9/20/2010	16:09	215.33
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.24	8/22/2011	16:02	216.88
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.99	9/1/2011	15:00	216.13
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		21.72	5/26/2012	16:47	220.40
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		23.72	9/10/2012	14:15	218.40
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.95	6/17/2015	15:13	215.17
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		NR	8/12/2015	NR	NR
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		28.61	9/2/2015	11:40	213.51
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD	33.11	28.32	9/10/2015	NR	213.80
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.29	8/14/2000	NR	198.20
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.63	9/5/2007	15:30	198.86
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.08	9/18/2008	11:35	198.41
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		17.90	6/19/2009	NR	199.59
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.29	10/7/2009	17:25	198.20
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.03	9/20/2010	13:22	198.46
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.78	8/24/2011	14:56	198.71
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.70	9/1/2011	15:09	198.79
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		16.25	5/26/2012	16:02	201.24
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.29	9/9/2012	11:45	199.20
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.24	6/17/2015	14:25	199.25

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.17	8/12/2015	11:03	198.32
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.20	9/2/2015	11:15	198.29
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD	26.19	19.18	9/10/2015	NR	198.31
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	8/14/2000	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.42	9/5/2007	14:00	260.47
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	9/18/2008	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.10	6/19/2009	NR	260.79
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	10/7/2009	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.40	9/21/2010	10:20	260.49
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.51	8/26/2011	9:12	261.38
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.97	9/1/2011	16:14	260.92
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.68	5/26/2012	13:36	261.21
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.57	9/9/2012	16:45	260.32
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		21.10	6/17/2015	12:25	259.79
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		21.97	8/12/2015	11:54	258.92
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		22.36	9/2/2015	10:50	258.53
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD	23.67	22.41	9/10/2015	NR	258.48
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.70	8/30/2011	9:21	317.62
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.65	9/1/2011	16:28	317.67
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		11.64	5/26/2012	13:23	319.68
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		12.74	9/9/2012	16:10	318.58
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.54	6/17/2015	12:41	317.78
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		14.87	8/12/2015	11:58	316.45
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		15.04	9/2/2015	10:35	316.28
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD	17.61	14.89	9/10/2015	NR	316.43
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		>31.56	8/29/2011	18:21	--
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		28.11	9/1/2011	16:43	249.17
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		26.67	5/26/2012	14:04	250.61
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.88	9/9/2012	15:30	249.40
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.81	9/11/2012	11:20	249.47
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.60	6/17/2015	11:31	249.68
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.93	8/12/2015	12:04	249.35
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		28.30	9/2/2015	10:00	248.98
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD	34.72	29.38	9/10/2015	NR	247.90
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		30.60	8/29/2011	16:15	245.61
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		29.17	9/1/2011	16:38	247.04
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		25.62	5/26/2012	14:14	250.59
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		26.39	9/9/2012	15:45	249.82
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		26.88	9/10/2012	11:35	249.33
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		28.98	6/17/2015	11:37	247.23
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		32.90	8/12/2015	12:09	243.31
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		33.52	9/2/2015	10:25	242.69
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD	63.54	31.02	9/10/2015	NR	245.19
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		Dry	8/29/2011	12:00	Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		Dry	9/1/2011	16:34	Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		22.60	5/26/2012	14:24	248.70
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.24	9/9/2012	16:00	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		23.69	6/17/2015	15:52	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.08	8/12/2015	12:11	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.36	9/2/2015	10:30	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry	25.70	24.16	9/10/2015	NR	Suspected Dry (Water Elevation <246.7 ft bgs)
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.72	8/31/2011	13:34	261.90
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.70	9/1/2011	16:20	261.92

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		2.46	5/26/2012	11:04	263.16
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.30	9/9/2012	16:39	262.32
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		5.02	6/17/2015	13:18	260.60
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		6.80	8/12/2015	11:46	258.82
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		6.98	9/2/2015	11:00	258.64
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD	17.68	5.97	9/10/2015	NR	259.65
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		30.05	8/30/2011	18:04	246.65
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		29.70	9/1/2011	16:09	247.00
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		18.41	5/26/2012	13:45	258.29
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		24.06	9/9/2012	16:50	252.64
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		29.85	6/17/2015	12:13	246.85
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		DRY	8/12/2015	11:51	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		DRY	9/2/2015	10:45	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD	31.70	DRY	9/10/2015	NR	Dry (Water Elevation <243.3 ft bgs)
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		30.51	8/31/2011	10:05	218.50
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		30.01	9/1/2011	16:00	219.00
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		24.40	5/26/2012	14:45	224.61
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		27.34	9/10/2012	17:35	221.67
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		19.64	8/30/2011	10:35	225.29
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		19.59	9/1/2011	15:56	225.34
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		18.33	5/26/2012	14:56	226.60
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		18.3	9/8/2012	13:00	226.63
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		13.84	8/30/2011	11:35	214.25
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		14.90	9/1/2011	15:50	213.19
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		6.17	5/26/2012	15:08	221.92
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		8.88	9/8/2012	14:30	219.21
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		13.13	6/18/2015	19:52	214.96
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		14.80	8/12/2015	12:19	213.29
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		15.19	9/2/2015	9:35	212.90
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD	24.14	14.81	9/10/2015	NR	213.28
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		15.00	8/30/2011	9:20	213.66
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		13.78	9/1/2011	15:52	214.88
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		8.20	5/26/2012	15:03	220.46
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		10.79	9/8/2012	16:20	217.87
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		15.03	6/18/2015	19:40	213.63
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		17.01	8/12/2015	12:18	211.65
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		17.28	9/2/2015	9:36	211.38
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD	55.02	19.93	9/10/2015	NR	208.73
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.66	8/31/2011	15:47	214.17
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.87	9/1/2011	15:37	213.96
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		21.82	5/26/2012	13:10	222.01
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		24.83	9/9/2012	17:20	219.00
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.17	6/17/2015	10:46	214.66
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		31.43	8/12/2015	12:31	212.40
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		31.65	9/2/2015	9:30	212.18
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD	41.57	31.20	9/10/2015	NR	212.63
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		19.47	9/1/2011	15:32	220.53
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		11.54	5/26/2012	12:59	228.46
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		16.02	9/9/2012	17:25	223.98

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		18.48	6/17/2015	10:31	221.52
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		23.48	8/12/2015	12:33	216.52
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		24.95	9/2/2015	9:20	215.05
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD	45.70	23.94	9/10/2015	NR	216.06
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		6.89	8/31/2011	8:53	208.31
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		6.97	9/1/2011	15:43	208.23
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		4.82	5/26/2012	15:26	210.38
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		5.53	9/9/2012	10:10	209.67
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		7.11	6/17/2015	10:18	208.09
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		7.92	8/12/2015	12:39	207.28
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		8.12	9/2/2015	9:10	207.08
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD	17.70	7.96	9/10/2015	NR	207.24
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.80	8/31/2011	10:16	201.33
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.82	9/1/2011	17:10	201.31
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		7.91	5/26/2012	15:36	202.22
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.29	9/8/2012	17:35	201.84
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.55	6/17/2015	10:08	201.58
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		9.10	8/12/2015	12:39	201.03
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		9.45	9/2/2015	9:00	200.68
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD	10.67	9.14	9/10/2015	NR	200.99
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.20	8/31/2011	11:08	196.90
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.48	9/1/2011	17:04	196.62
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		5.55	5/26/2012	15:44	199.55
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		7.77	9/9/2012	17:35	197.33
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.47	6/17/2015	9:46	196.63
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		10.01	8/12/2015	12:43	195.09
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		10.33	9/2/2015	8:50	194.77
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD	17.74	10.19	9/10/2015	NR	194.91
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.02	8/30/2011	16:31	188.14
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.01	9/1/2011	15:14	188.15
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		14.60	5/26/2012	15:56	189.56
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		15.56	9/9/2012	17:47	188.60
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		15.88	6/17/2015	14:15	188.28
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.92	8/12/2015	11:06	187.24
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.63	9/2/2015	11:10	187.53
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD	30.95	16.54	9/10/2015	NR	187.62
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.70	8/30/2011	14:51	205.81
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.61	9/1/2011	15:06	205.90
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		14.59	5/26/2012	16:15	208.92
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		16.45	9/9/2012	14:00	207.06
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		16.89	6/17/2015	14:31	206.62
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.88	8/12/2015	10:58	205.63
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		19.02	9/2/2015	11:12	204.49
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD	32.30	17.88	9/10/2015	NR	205.63
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.85	8/30/2011	18:02	207.91
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.88	9/1/2011	14:50	207.88
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		29.74	5/26/2012	16:22	210.02
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		33.87	9/9/2012	10:30	205.89
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.81	6/17/2015	14:40	207.95
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		32.48	8/12/2015	10:56	207.28
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		32.60	9/2/2015	11:20	207.16
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD	44.43	32.45	9/10/2015	NR	207.31
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.25	8/30/2011	11:35	209.68

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.30	9/1/2011	14:47	209.63
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		32.76	5/26/2012	16:30	213.17
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		34.01	9/9/2012	17:55	211.92
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.04	6/17/2015	14:48	209.89
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.98	8/12/2015	10:50	208.95
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		37.24	9/2/2015	11:25	208.69
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD	45.13	36.42	9/10/2015	NR	209.51
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		30.30	8/30/2011	16:50	212.64
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		30.37	9/1/2011	14:58	212.57
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		26.28	5/26/2012	16:38	216.66
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		28.64	9/9/2012	12:50	214.30
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		34.41	6/17/2015	14:58	Suspected Dry (Water Elevation <208.4 ft)
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		NR	8/12/2015	NR	--
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		31.42	9/2/2015	22:30	211.52
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD	35.77	31.24	9/10/2015	NR	211.52
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		25.50	8/30/2011	14:57	216.44
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		28.61	9/1/2011	14:53	213.33
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		24.19	5/26/2012	16:41	217.75
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		27.01	9/10/2012	15:43	214.93
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		28.90	6/17/2015	15:08	213.04
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		29.88	8/12/2015	10:46	212.06
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		30.10	9/2/2015	11:35	211.84
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD	65.87	29.95	9/10/2015	NR	211.99
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		63.21	9/1/2011	13:20	219.04
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		52.65	5/26/2012	17:09	229.60
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		61.20	9/9/2012	16:22	221.05
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		64.08	6/17/2015	15:41	218.17
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		66.60	8/12/2015	11:12	215.65
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		66.89	9/2/2015	12:11	215.36
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD	71.75	66.81	9/10/2015	NR	215.44
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		53.53	9/1/2011	14:35	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		52.63	5/26/2012	16:58	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		NR	9/9/2012	NR	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.25	6/17/2015	19:33	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.28	8/12/2015	11:19	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.32	9/2/2015	12:15	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD	55.63	54.45	9/10/2015	NR	Suspected Dry (Water Elevation <223.7 ft)
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		37.75	8/29/2011	13:51	460.24
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		37.51	9/1/2011	14:05	460.48
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		34.12	5/26/2012	10:10	463.87
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		36.29	9/9/2012	18:10	461.70
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		39.31	6/22/2015	19:09	458.68
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		42.25	8/12/2015	11:31	455.74
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		43.07	9/2/2015	12:45	454.92
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD	47.10	41.75	9/10/2015	NR	456.24
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		18.90	8/31/2011	15:55	177.68
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		18.86	9/1/2011	15:26	177.72
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		16.71	5/26/2012	12:45	179.87
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		17.21	9/8/2012	15:40	179.37
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		19.03	6/17/2015	9:30	177.55
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		19.49	8/12/2015	12:47	177.09
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		20.17	9/2/2015	12:45	176.41
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD	26.73	20.05	9/10/2015	NR	176.53

Table 2-2 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	GW Encountered During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below TOC)	Date	Time	
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.14	8/31/2011	17:57	170.78
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.19	9/1/2011	15:20	170.73
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		3.98	5/26/2012	12:33	174.94
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		5.97	9/8/2012	12:30	172.95
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.50	6/17/2015	14:04	170.42
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		9.05	8/12/2015	11:09	169.87
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		9.23	9/2/2015	8:40	169.69
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD	24.26	9.12	9/10/2015	NR	169.80
MW34	AST5 MW1	NR	NR	290.95	294.25			15.57	9/1/2011	16:49	278.68
MW34	AST5 MW1	NR	NR	290.95	294.25			15.82	6/22/2015	11:54	278.43
MW34	AST5 MW1	NR	NR	290.95	294.25			17.11	9/2/2015	10:20	277.14
MW34	AST5 MW1	NR	NR	290.95	294.25		22.80	16.38	9/10/2015	NE	277.87
MW35	AST5 MW2	NR	NR	285.76	289.26			41.97	9/1/2011	16:55	247.29
MW35	AST5 MW2	NR	NR	285.76	289.26			40.01	6/22/2015	11:58	249.25
MW35	AST5 MW2	NR	NR	285.76	289.26			44.94	9/2/2015	10:15	244.32
MW35	AST5 MW2	NR	NR	285.76	289.26		55.30	44.42	9/10/2015	NR	244.84
MW36	AST5 MW3	NR	NR	286.33	290.03			35.81	9/1/2011	16:57	254.22
MW36	AST5 MW3	NR	NR	286.33	290.03			33.16	6/22/2015	12:08	256.87
MW36	AST5 MW3	NR	NR	286.33	290.03			40.89	9/2/2015	10:10	249.14
MW36	AST5 MW3	NR	NR	286.33	290.03		65.38	39.39	9/10/2015	NR	250.64
MW39	SM67	84.0	63 - 83	432.83	435.26			85.11	8/3/2015	9:00	Suspected Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26			Dry (>84)	8/12/2015	11:25	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26			Dry (>84)	9/2/2015	12:35	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26		86.02	Dry (>84)	9/10/2015	NR	Dry (Water Elevation <349.8 ft)
MW40	SM68c	140.0	119 - 139	392.86	395.18	135		131.11	8/12/2015	11:37	264.07
MW40	SM68c	140.0	119 - 139	392.86	395.18	135		131.49	9/2/2015	12:25	263.69
MW40	SM68c	140.0	119 - 139	392.86	395.18	135	142.45	131.60	9/10/2015	NR	263.58
MW42	SM70b	140.0	119 - 139	339.85	342.34	99		NR	8/12/2015	NR	
MW42	SM70b	140.0	119 - 139	339.85	342.34	99		129.10	9/2/2015	11:50	213.24
MW42	SM70b	140.0	119 - 139	339.85	342.34	99	142.97	129.01	9/10/2015	NR	213.33
MW43	SM71b	118.5	98 - 118	300.87	303.69	94		90.25	8/12/2015	10:33	213.44
MW43	SM71b	118.5	98 - 118	300.87	303.69	94		90.42	9/2/2015	12:00	213.27
MW43	SM71b	118.5	98 - 118	300.87	303.69	94	121.13	90.34	9/10/2015	NR	213.35

Notes

Elevation datum: NAVD88 calculated using GEOID09.

Top of casing (TOC) refers to the top of PVC inner casing.

Key

NR	Not Recorded
TD	Total depth
TOC	Top of Casing
bgs	Below ground surface

Table 2-3 Surface Water Sample Collection

Sample Location ID	Location Description	Sample Analyses and Methods									
		Total TAL Metals EPA 6010B/6020A / 7470A	Dissolved TAL Metals EPA 6010B/6020A /7470A	Total Low Level Hg EPA 1631E	Dissolved Low-Level Hg EPA 1631E	Total Organic Carbon SW846 9060	Total Suspended Solids SM 2540D	Total Dissolved Solids SM 2540C	Inorganic Ions MCAWW 300.0	Carbonate Alkalinity as CaCO3 SM 2320B	Nitrate Nitrite as N MCAWW 353.2
RD01SW	Red Devil Creek, upstream of the reservoir	X	X	X	X	X	X	X	X	X	X
RD14SW	Red Devil Creek, new station immediately upstream of the newly aligned section (post-NTCRA) of Red Devil Creek, near former station RD04SW	X	X	X	X	X	X	X	X	X	X
RD15SW	Red Devil Creek, new station immediately downstream of the newly aligned section (post-NTCRA) of Red Devil Creek, near former baseline monitoring station RD13SW	X	X	X	X	X	X	X	X	X	X
RD05SW	Seep on left bank of Red Devil Creek	X	X	X	X	X	X	X	X	X	X
RD09SW	Red Devil Creek, near Settling Pond #2	X	X	X	X	X	X	X	X	X	X
RD06SW	Red Devil Creek, near Settling Pond #3	X	X	X	X	X	X	X	X	X	X
RD08SW	Red Devil Creek, near confluence of Red Devil Creek and Kuskokwim River, downstream of sediment trap constructed during NTCRA	X	X	X	X	X	X	X	X	X	X

Key:

EPA = Environmental Protection Agency
Hg = Mercury
MCAWW = Methods for Chemical Analysis of Water and Wastes
TAL = Target Analyte List

3 Sample Identification

Each sample collected during baseline monitoring will be assigned a unique alphanumeric code. Sample codes will be recorded in field logbooks, on sample containers, and on chain-of-custody (COC) forms. The field team leader will be responsible for maintaining a master database or spreadsheet of samples to be collected and samples obtained to ensure that all planned samples are collected during the field investigation, that sample designation codes are not used twice for different locations, and that the correct analytical parameters are identified on laboratory documentation.

Tables 3-1 and 3-2 describe the sample coding system.

Groundwater

Groundwater samples will be collected for laboratory analyses from selected existing monitoring wells. Groundwater samples will be collected from the wells identified in Table 2-1, and shown on Figure 2-1. Groundwater samples will be assigned sample identifiers as specified in Table 3-1.

Table 3-1 Sample Identification Coding System: Groundwater

Characters	Purpose	Code	Description
1–2	Sample collection month	XX	Numerical month designation (e.g., “05” for May)
3–4	Sample collection year	XX	Last two digits of year (e.g., “17” for 2017)
5–8	Monitoring well identification number	MW08, etc.	See Table 2-1 and Figure 2-1 for descriptions and locations of existing monitoring well IDs.
9–10	Matrix	GW	Groundwater

Field duplicate samples for groundwater samples will be identified by selecting a unique monitoring well identification number not used for any actual monitoring wells. All samples will be cross-referenced in the field logbooks and in the sample master database to monitoring well designations.

Example sample codes for groundwater:

- 0517MW08GW: The regular groundwater sample collected from existing monitoring well MW08 in May 2017.
- 0517MW90GW: The field duplicate groundwater sample collected from existing monitoring well MW08 in May 2017.

Surface Water

Surface water samples will be assigned sample identifiers as specified in Table 3-2. Pre-assigned sample location identifiers for planned surface water samples are presented in Table 2-3 and on Figure 2-1.

Table 3-2 Sample Identification Coding System: Surface Water

Characters	Purpose	Code	Description
1–2	Sample collection month	XX	Numerical month designation (e.g., “05” for May)
3–4	Sample collection year	XX	Last two digits of year (e.g., “16” for 2017)
5–8	Surface water monitoring station identification number	RD10, etc.	See Table 2-3 and Figure 2-1 for descriptions and locations of existing surface water monitoring stations.
9–10	Matrix	SW	Surface water

Field duplicate samples for surface water samples will be identified by selecting a unique location number not used for any actual samples. All samples will be cross-referenced in the field logbooks and in the sample master database to sample locations.

Example sample codes for surface water:

- 0517RD08SW: The regular surface water sample collected from surface water sampling station RD08 in Red Devil Creek in May 2017.
- 0517RD20SW: The field duplicate surface water sample collected from surface water sampling station RD08 in Red Devil Creek in May 2017.

4 Sampling and Other Field Procedures

This chapter describes the procedures and equipment to be used in the collection of samples and field observations during the baseline monitoring activities. The organization performing the baseline monitoring will have standard operating procedures (SOPs) for the activities specified that reflect current industry practices and standards. Copies of all applicable SOPs will be on site during the implementation of the baseline monitoring field work.

All surface water and groundwater sampling conducted for the baseline monitoring will be conducted using ultraclean sampling methods (U.S. Environmental Protection Agency [EPA] Method 1669). In summary, ultraclean sampling methods involve the following procedures:

- Sampling equipment and containers that have been cleaned using detergent, mineral acids, and reagent water; filled with weak acid solution; and individually double-bagged for storage and shipment are obtained from the laboratory.
- On site, one member of the two-person sampling team is designated as "dirty hands," the second member as "clean hands." All operations involving contact with the sample container and transfer of the sample from the sample collection device to the sample container are handled by the "clean hands" individual."
- A new pair of 8-millimeter nitrile gloves will be worn during each sample collection.
- All sampling equipment and sample containers used will be non-metallic and free from any material that may contain metals.
- Sampling personnel will wear clean, non-talc gloves when handling sampling equipment and sample containers.
- Surface water samples will be collected facing upstream and upwind (when possible) to minimize introduction of contamination.
- Acid preservatives will be placed in sample containers in a clean area prior to sample collection.

4.1 Monitoring Well Development

It was not possible to develop monitoring well MW39 during the 2015 RI Supplement field event because it contained insufficient water. This well will be inspected during the initial baseline monitoring event and will be developed if feasible.

Well development will be accomplished by a combination of mechanical surging, bailing, and pumping with a submersible pump. The wells will be mechanically surged, depending on the geologic characteristics of the screened interval, to remove fines from inside the screen and casing and to flush the formation around the filter pack throughout the entire screened interval. Fines will be removed from the borehole periodically during the surging process using a bailer to minimize the re-entry of fines into the formation. The monitoring wells will then be pumped with a submersible pump until the measured water quality parameters are stabilized. Water will be removed throughout the entire water column by periodically lowering and raising the pump intake. Development will be considered complete when a minimum of 5 to 10 well-bore volumes have been removed from the well, and the water is chemically stable and as free of sediment as possible. Water produced from the well will be considered chemically stable when field parameters (pH, temperature, specific conductance, and turbidity) remain within 10 percent of the previous measurement for at least three successive measurements. Water produced from the well will be considered free of sediment when it is clear or turbidity has stabilized for at least three successive borehole measurements. The pump, tubing, and all other equipment used during development will be decontaminated between each use. The development water will be disposed of as described in Section 7.3.

4.2 Groundwater Level Measurement

Prior to groundwater sampling, a round of static water level measurements will be performed at each well. Depth to groundwater will be measured to the nearest 0.01 foot using an electronic water level meter. The locking cover and protective cap will be removed, and the static water level depth will be measured from the surveyed measuring point (usually the north side of the top of the inside well casing). If the casing cap is airtight as evidenced by release or drawing of air upon removal of the well cap, time will be allowed prior to water level measurement for equilibration of pressures after the cap is removed. Measurements will be repeated until the water level is stabilized. The water level meter will be cleaned with an environmental grade non-phosphate detergent before sounding the well. All parts of the water level meter that will contact groundwater will be rinsed with distilled water before placement in the well. Groundwater levels in all monitoring wells will be measured within as short a period of time as feasible, not to exceed one day, in order to provide data representative of the potentiometric surface(s) at the time of the monitoring event. The water level measurements will be used to determine groundwater elevation and estimate the standing water volume contained within the well. The measurement will also be used to determine the depth of the pump intake and to monitor water drawdown during purging and sampling, as described below.

4.3 Groundwater Sampling

During the baseline monitoring, groundwater samples will be collected from existing monitoring wells specified in Table 2-1. To the extent practicable, groundwater sampling will occur in a progression from the least to the most contaminated wells, based on existing groundwater sample data.

In general, each well will be sampled following the EPA's Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001 (EPA 2002). The expected sampling approach is specified below.

Groundwater purging and sampling will be performed using a low-flow technique at each well, if feasible. If it is determined that it is not feasible to use a low-flow technique at a given well, the well will be purged utilizing an alternate technique with a pump and/or disposable bailers as described below.

Low-Flow Purging Technique

Low-flow purging/sampling will be performed following the EPA's Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001 (EPA 2002) and Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (Puls and Barcelona, 1996). Low-flow purging and sampling will be performed using a submersible pump, a bladder pump, or a battery-operated peristaltic pump outfitted with certified clean, dedicated, disposable tubing.

The tubing/pump intake will be carefully lowered into the well to the targeted sample point (e.g., at the middle of the water column within the screen interval). The well will be purged at a target rate of less than 0.5 liter per minute. During purging, the water level will be monitored with the water level indicator to measure well drawdown and guide the adjustment of purge rate to minimize drawdown while purging. The water level will be monitored continuously during purging, and the sampling team will attempt to maintain less than 0.1 meter of drawdown during purging.

During purging, field water quality parameters, including pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity, will be measured to determine when stabilization of the groundwater is achieved. Water quality parameters will be measured using an in-line water quality meter (e.g., Horiba U50 or similar equipment) and recorded in the field logbook. Field parameters will be measured every 3 to 5 minutes during purging. Field parameters will be considered stabilized after all parameters have stabilized for three successive readings. Criteria for stabilization are three successive readings within the following limits:

- pH: ±0.1 pH units;
- Temperature: ±1 degree Celsius (°C);
- Specific electrical conductance (conductivity): ±3%;

- Turbidity: ±10% (when turbidity is greater than 10 nephelometric turbidity units);
- Dissolved oxygen: ±0.3 milligrams per liter; and
- Oxidation Reduction Potential: ±10 millivolts.

Upon stabilization of field parameters, groundwater samples will be collected directly into the appropriate (pre-preserved, as applicable) sample containers.

The use of peristaltic pumps to collect groundwater samples is limited by the ability of peristaltic pumps to draw water from depths of greater than approximately 25 feet. If it is not possible to collect a groundwater sample from a given well using a peristaltic pump, the sampling team will attempt to use a decontaminated, positive-pressure pump (bladder pump or electric submersible pump) to purge and sample the well using low-flow techniques.

Following successful purging, samples will be collected as described below.

If the drawdown and/or field water quality parameter criteria cannot be met, then the well will be sampled using an alternate purging technique, described below.

Alternate Purging Technique

If the low-flow technique is not successful at a given well, purging will be accomplished using a positive pressure pump (e.g., submersible pump) and/or a dedicated, disposable Teflon-lined bailer. A minimum of three casing volumes of water will be purged prior to sample collection unless the well runs out of recoverable water. Field water quality parameters will be measured in the first water extracted from the well and subsequently after each time a casing volume is purged. If a bailer is used, water quality parameters will be measured by pouring a volume of water from a bailer into a container and submerging the water quality meter probe into the container. It may not be possible to achieve the stabilization criteria outlined above using a bailer to purge the well. In this case, sample collection will be performed after six well volumes have been purged from the well.

In the event that the well runs dry during purging, the well will be allowed to recharge for up to 24 hours. Upon resumption of pumping, field water quality parameters will be measured and samples will be immediately collected.

Sample Collection

Samples will be collected for the parameters specified in Table 2-1. Samples will be collected in bottles provided by the analytical laboratory. Bottle sets will be filled in the following general order: non-filtered, non-preserved aliquots; followed by non-filtered preserved aliquots; followed by filtered, non-preserved aliquots; followed by filtered preserved aliquots. Aliquots for dissolved constituents will be field-filtered using a dedicated 0.45-micrometer filter.

Samples collected using a low-flow purging technique will be collected immediately following stabilization of water quality parameters with the pump still running at the stabilized purge rate. For filtered aliquot collection, the filter will be inserted into the end of the sample tubing while the pump is still running in order to maintain a steady flow of water, minimizing potential disturbance of formation groundwater. Following installation of the filter, water will be allowed to run through the filter for several filter volumes prior to sample collection. The dissolved sample aliquot will then be collected directly into the appropriate sample container.

Samples collected by bailer will be poured directly into the appropriate pre-cleaned sample containers. Filtered aliquots will be collected by pouring water from the bailer into a dedicated transfer container and pumping the water into the sample container using a peristaltic pump outfitted with dedicated tubing and in-line 0.45 micrometer filter.

4.4 Surface Water Sampling

Surface water samples will be taken from locations specified in Table 2-3 and illustrated in Figure 2-1, including locations along Red Devil Creek and the seep on the left bank of the creek. Sampling will start at the most downstream location and proceed upstream to avoid disturbing sediments that could impact turbidity and contaminant concentrations in downstream locations.

Samples will be collected for the analytical parameters specified in Table 2-3. Samples will be collected in bottles provided by the analytical laboratory. Bottle sets will be filled in the following general order: non-filtered, non-preserved aliquots; followed by non-filtered preserved aliquots; followed by filtered, non-preserved aliquots; followed by filtered preserved aliquots. Aliquots for dissolved constituents will be field-filtered using a dedicated 0.45-micrometer filter.

Samples will be collected using a battery-operated peristaltic pump outfitted with certified clean, dedicated, disposable tubing. The water sample will be collected from a single location within the middle of the stream channel at the mid-depth water level. Dissolved metals aliquots will be collected following collection of the other aliquots using a dedicated in-line 0.45-micrometer filter.

In the event that it is not possible to collect the water samples using a peristaltic pump, the samples will be collected by hand-dipping the sample container directly into the creek water. For sample containers that have been pre-preserved, a separate dedicated bottle may be used as a transfer container.

Following sample collection at each location, field parameters for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity will be measured using a calibrated water quality meter and then recorded in the field logbook.

4.5 Stream and Seep Discharge Measurement

Surface water discharge will be measured using the Mid-Section method at each surface water sampling location where the estimated discharge is greater than 2.0 cubic feet per second (cfs) and a portable weir plate will be used for stream sections with smaller discharge rates. Based on 2011 RI stream gaging results, it is anticipated that stream discharge rates at Red Devil Creek monitoring locations will be greater than 2.0 cfs and that the discharge at the seep location (RD05) may be less than 2.0 cfs. Discharge will be measured in accordance with Measurement and Computation of Streamflow: Volume 1, Measurement of Stage and Discharge (Rantz et al. 1982) and Techniques of Water-Resources Investigations Reports (USGS 2011). The planned measurement methods are discussed further below.

4.5.1 Measurement Methods

The following sections detail the methods to be used. Field staff will determine which of the two proposed methods will be applied based on the flow rate during the measurement event.

4.5.1.1 Mid-Section Method

The Mid-Section method involves measuring the channel area and water velocities at a stream cross section. This method will be used where sufficient stream flow is available to allow the channel to be divided into rectangular subsections. After dividing the stream into subsections, the depth, discharge, and distance from the bank will be measured at the center of the stream subsection.

In general, the preferred number of subsections across the width of the stream is 20 to 30, with a minimum of 10. If the stream width is less than 5 feet, the width of the subsections should not be less than 0.5 foot. Not more than 5 percent of stream discharge should occur within a single subsection. Subsections do not have to be the same width. For water depths greater than 2.5 feet, velocity will be measured at two depths, 20 and 80 percent of the total subsection depth, and averaged. For water depths less than 2.5 feet, velocity only will be measured at 60 percent of the total subsection depth.

Appropriate locations for stream cross sections are straight reaches where the streambed is uniform, free of boulders and aquatic vegetation, and where the stream flow is uniform.

4.5.1.2 Portable Weir Plates

Portable weir plates will be used where Red Devil Creek is too small or velocities too low to reliably use the Mid-Section method described above. This is typically where stream widths are shallow and flows are less than 2.0 cfs. Weir plates are constructed with a staff gage on the upstream side, far enough away from the notch so it is not impacted by the drawdown of flow through the notch. Once a steady-state discharge through the weir has been reached, the height behind the weir plate is recorded to determine the flow rate through the weir. These are intended to be short-term measurement devices and are removed after each use.

4.5.2 Discharge Calculation

The general equation for calculating discharge is:

Discharge (Q) = Velocity (v) x Cross sectional area of stream channel (A)

For the Mid-Section method, stream discharge will be calculated for each subsection (q) and then summed together to obtain total discharge (Q).

$q_{1,2,3,etc.} = V_{1,2,3,etc.}$ x Depth at $\text{Midpoint}_{1,2,3,etc.}$ x Width of $\text{Subsection}_{1,2,3,etc.}$

and,

$Q = q_1 + q_2 + q_3 + q_{etc.}$

For the Portable Weir Plate method, the following equation will be used:

Q = Ch^(5/2)

where,

Q = Discharge (cfs)
h = Static head above the bottom of the notch (mean gage height), in feet
C = Coefficient of discharge. A standard value of 2.47 will be used for C assuming a 90 degree notched V-weir.

4.5.3 Equipment

Stream discharge measurement will require the following equipment:

Mid-Section Method: A Marsh McBirney or similar flow meter, top-setting wading rod, long tape measure, waders, and calculator.

Portable Weir Plate: Portable weir plate, constructed to U.S. Geological Survey standard specifications, shovel, carpenter’s level, rebar to stabilize the weir (as needed), and canvas or similar to prevent downstream undercutting.

4.5.4 Stream Measurements

4.5.4.1 Mid-Section Method

After identifying a suitable location for the stream cross section, a reference point on one bank will be selected. A tape measure will be stretched across the stream, fixing it to the reference point on one bank and another point on the opposite bank, while ensuring that the tape is oriented perpendicular to the stream flow.

Using the measured channel width, the appropriate number of subsections will be determined based on the guidelines in Section 4.5.1.

From the mid-point of each subsection, the stream velocity will be measured at the depths provided in Section 4.5.1. When measuring the stream velocity, the wading rod and flow meter should be located upstream from the field personnel to ensure that stream flow is not disrupted.

Discharge will then be calculated as described in Section 4.5.2, and the velocity of each subsection will be checked to ensure that it is less than 5 percent of the total stream discharge. If any subsection contains more than 5 percent of the stream discharge, additional subsections will be measured.

4.5.4.2 Portable Weir Plate

The weir plate will be pushed into the stream bed perpendicular to the flow, with an effort made to channel all of the stream flow through the weir by using stream bed material to pack around the weir and/or channelize the flow towards the opening of the weir plate. As needed, an estimation of flow around the weir will be made and noted. A carpenter's level will then be used to ensure that the weir is level. This will be done to provide an accurate and consistent measurement relative to the water surface. Weir plates will not be submerged on either the up or downstream sides, also to increase accurate readings.

Once the pool height has stabilized on the upstream side of the weir, gage readings will be recorded every 30 seconds for three minutes. The mean value of these readings will then be used to compute discharge.

5 Sample Analytical Methods

Sample analytical methods, including holding times and method detection limits, are presented in the QAPP, provided as Appendix B of the Work Plan. For reference, Table 5-1 summarizes the sample analytical methods.

Table 5-1 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Matrix: Groundwater/Surface Water		
Analytical Group: Metals		
Total and Dissolved Metals	▪ Mercury (low level)	▪ EPA 1631E
	▪ Aluminum	▪ EPA 6010B
	▪ Antimony	▪ EPA 6020A (mass=121)
		▪ EPA 6020A (mass=123)
	▪ Arsenic	▪ EPA 6020A
	▪ Barium	▪ EPA 6020A (mass=135)
		▪ EPA 6020A (mass=137)
	▪ Beryllium	▪ EPA 6020A
	▪ Cadmium	▪ EPA 6020A (mass=111)
		▪ EPA 6020A (mass=114)
	▪ Calcium	▪ EPA 6010B
	▪ Chromium	▪ EPA 6020A (mass=52)
		▪ EPA 6020A (mass=53)
	▪ Cobalt	▪ EPA 6020A
	▪ Copper	▪ EPA 6020A (mass=63)
		▪ EPA 6020A (mass=65)
	▪ Iron	▪ EPA 6010B (mass=54)
		▪ EPA 6010B (mass=57)
	▪ Lead	▪ EPA 6020A
	▪ Magnesium	▪ EPA 6010B
	▪ Manganese	▪ EPA 6010B
	▪ Nickel	▪ EPA 6020A (mass=60)
		▪ EPA 6020A (mass=62)
	▪ Potassium	▪ EPA 6010B
	▪ Selenium	▪ EPA 6020A (mass=82)
		▪ EPA 6020A (mass=78)
	▪ Silver	▪ EPA 6020A
	▪ Sodium	▪ EPA 6010B
	▪ Thallium	▪ EPA 6020A
	▪ Vanadium	▪ EPA 6020A
	▪ Zinc	▪ EPA 6020A (mass=66)
		▪ EPA 6020A (mass=67)
		▪ EPA 6020A (mass=68)
Analytical Group: Petroleum		
	▪ Gasoline Range Organics	▪ AK 101
	▪ Diesel Range Organics	▪ AK 102
Analytical Group: Volatile Organic Compounds		
	▪ Benzene	▪ EPA 8021B / EPA 8260
	▪ Toluene	▪ EPA 8021B / EPA 8260
	▪ Ethylbenzene	▪ EPA 8021B / EPA 8260
	▪ m/p-Xylene	▪ EPA 8021B / EPA 8260
	▪ o-Xylene	▪ EPA 8021B / EPA 8260
Analytical Group: Semivolatile Organic Compounds		
	▪ SVOCs	▪ EPA 8270D

Table 5-1 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Analytical Group: Conventionals		
	▪ Sulfate ▪ Chloride ▪ Fluoride ▪ Nitrate/Nitrite ▪ Carbonate/Bicarbonate ▪ Total Suspended Solids ▪ Total Dissolved Solids ▪ Total Organic Carbon	▪ EPA 300.0 ▪ EPA 300.0 ▪ EPA 300.0 ▪ EPA 353.2 ▪ EPA 310.1/SM2320B ▪ EPA 160.2/SM2540D ▪ EPA 160.1/SM2540D ▪ EPA 9060

Key:
EPA = U.S. Environmental Protection Agency
SVOCs = semivolatile organic compounds

6 Sample Handling, Preservation, and Shipping

Transportation and handling of samples must be accomplished in a manner that not only protects their integrity but also prevents any detrimental unnecessary exposure to sample handlers due to the possibly hazardous nature of the samples.

6.1 Sample Documentation

6.1.1 Sample Labels

Sample labels attached to or fixed around the sample container will be used to identify all samples collected in the field. The sample labels will be placed on bottles so as not to obscure any quality assurance/quality control (QA/QC) lot numbers on the bottles, and sample information will be printed legibly. Field identification will be sufficient to enable cross-reference with the project logbook.

To minimize handling of sample containers, labels will be filled out before sample collection. Each sample label will be written in waterproof ink, attached firmly to the sample containers, and protected with Mylar tape. The sample label will contain the following information:

- Sample designation code
- Date and time of collection
- Analysis required
- pH and preservation (when applicable)

6.1.2 Custody Seals

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Sample shipping containers (e.g., coolers) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Upon the containers' arrival at the laboratory, the custodian will check (and certify by completing the package receipt log) that seals are intact.

6.1.3 Chain-of-Custody Records

The COC records will be completed fully, at least in duplicate, by the field technician designated by the site manager as responsible for sample shipment. Information in the COC record will contain the same level of detail found in the site logbook, except that the onsite measurement data will not be recorded. The custody record will include, among other things, the following information:

- Name and company or organization of person collecting the samples;
- Date of sample collected;
- Matrix of sample collected (soil/water);
- Location of sampling station (using the sample designation code system described in Chapter 3);
- Number and type of containers shipped;
- Analysis requested; and
- Signature of the person relinquishing samples to the transporter, with the date and time of transfer noted, and signature of the designated sample custodian at the receiving facility.

If samples require rapid laboratory turnaround, the person completing the COC record will note these or similar requirements in the remarks section of the record.

The relinquishing individual will record pertinent shipping data (e.g., air-bill number, organization, time, and date) on the original custody record, which will be transported with the samples to the laboratory and retained in the laboratory's file. Original and duplicate custody records with the air bill or delivery note constitute a complete custody record. The field team leader will ensure that all records are consistent and that they are made part of the permanent job file.

6.1.4 Field Logbooks and Data Forms

Field logbooks (or daily logs) and data forms are necessary to document daily activities and observations. Documentation will be sufficient to enable reconstruction of events that occurred during the project accurately and objectively at a later time. All daily logs will be kept in a bound notebook containing numbered pages, and all entries will be made in waterproof ink, dated, and signed. No pages will be removed for any reason.

If corrections are necessary, they will be made by drawing a single line through the original entry (so that the original entry is still legible) and writing the corrected entry alongside it. The correction will be initialed and dated. Corrected errors may require a footnote explaining the correction.

6.1.5 Photographs

Photographs will be taken as directed by the team leader. Documentation of a photograph is crucial to ensure its validity as a representation of an existing situation.

The following information on photographs will be noted in field logbooks:

- Date, time, and location photograph was taken;
- Weather conditions;
- Description of photograph;
- Reasons photograph was taken;
- Sequential number of photograph; and
- Direction.

After the photographs are processed, the information recorded in the field logbook will be summarized in captions in the digital photo log.

6.1.6 Custody Procedures

The primary objective of COC procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is considered to be in custody if it is:

- In someone’s physical possession,
- In someone’s view,
- Locked up, and
- Kept in a secured area that allows authorized personnel only.

6.1.6.1 Field Custody Procedures

The following guidance will be used to properly control samples during fieldwork:

- As few people as possible will handle samples.
- Coolers or boxes containing cleaned bottles will be sealed with custody tape during transport to the field or while in storage before use. Sample bottles from unsealed coolers or boxes, or bottles that appear to have been tampered with, will not be used.
- The sample collector will be responsible for the care and custody of samples until they are transferred to another person or dispatched properly under COC rules.
- The sample collector will record sample data in the field logbook.
- The site team leader will determine whether proper custody procedures were followed during the fieldwork and decide whether additional samples are required.

When custody is transferred (e.g., samples are released to a shipping agent), the following will apply:

- The coolers in which the samples are packed will be sealed and accompanied by two COC records. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the COC record. This record documents sample custody transfer.
- Samples will be dispatched to the laboratory for analysis with separate COC records accompanying each shipment. Shipping containers will be sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information will be entered in the COC record.
- All shipments will be accompanied by COC records identifying their contents. The original record will accompany the shipment. The other copies will be distributed appropriately to the site team leader and site manager.
- If samples are sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

6.1.6.2 Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter preliminary information about the package into a package or sample receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (e.g., broken versus unbroken). Additional details on laboratory custody procedures are found in the QAPP.

6.2 Sample Containers and Preservation

Sample aliquots submitted to the analytical laboratories will be placed in commercial certified pre-cleaned sample containers and preserved as identified in Table 6-1.

6.3 Sample Shipping

Due to the remote location of the RDM site, sample shipment to the analytical laboratories will require careful logistical planning to ensure sample holding times are not exceeded and that samples arrive at the laboratories in good condition. In general, sample shipping logistics will involve the following:

- The field team leader will keep records of sample collection dates. Based on the dates of samples being held on site and the number of samples ready for shipment, the field team leader will contact E & E's Anchorage-based sample custodian to notify an aircraft charter service that a sample shipment flight is needed.

- When the sample shipment aircraft arrives at the Red Devil airstrip, the field team leader will relinquish custody of the samples to the pilot.
- When the sample shipment aircraft arrives in Anchorage, an Anchorage-based sample custodian will assume custody of the samples. The custodian will re-pack all sample shipping containers with fresh ice and relinquish custody of the samples to an overnight delivery service that will ship the samples to the analytical laboratories.
- The Anchorage-based sample custodian will confirm with the laboratories that all shipped samples have been received.

Table 6-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Typical Sample Containers
Water	Total TAL Inorganic Elements	6 months (28 days for Hg)	HNO_3, pH<2, 0–4°C	500-mL plastic bottle
	Dissolved TAL Inorganic Elements	6 months	HNO_3, pH<2, 0–4°C	500-mL plastic bottle
	Total Low-Level Hg	90 days	HNO_3, pH<2, 0–4°C (BrCl in lab within 28 days of collection for low-level Hg)	500-mL (for MS/MSD sample) or 250-mL plastic bottle; pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids
	Dissolved Low-Level Hg	90 days	HNO_3, pH<2, 0–4°C (BrCl in lab within 28 days of collection for low-level Hg)	500-mL (for MS/MSD sample) or 250-mL plastic bottle; pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids
	Total Organic Carbon	28 days	HCl or H_2SO_4 to pH <2, cool to 4°C ± 2°C	1-L HDPE
	Total suspended solids	7 days	Cool to 6°C	1-L HDPE
	Total dissolved solids	7 days	Cool to 6°C	1-L HDPE
	Inorganic Ions (chloride, fluoride, sulfate)	28 days	Cool to 4°C	HDPE
	Carbonate/Bicarbonate	14 days	Cool to 6°C	500 mL HDPE
	Nitrate/Nitrite as N	28 days	2 mL H_2SO_4 per liter. Cool to 6°C	500 mL or 1-L HDPE
	SVOCs	7 days for extraction, 40 days after extraction for analysis	None, 0–4°C	1-L amber bottle
	DRO	7 days for extraction, 40 days after extraction for analysis	None, 0–4°C	1-L amber bottle
	GRO and BTEX	14 days preserved, 7 days unpreserved.	HCl to pH <2, cool to 4°C	Four 40-mL amber glass vials, no headspace

Table 6-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Typical Sample Containers

Key:

°C = degrees Celsius
BrCl = bromine monochloride
BTEX = benzene, ethylbenzene, toluene, and xylenes
DRO = diesel range organics
GRO = gasoline range organics
HCl = hydrochloric acid
Hg = mercury
HDPE = high density polyethylene
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
L = liter
mL = milliliter
MS/MSD = matrix spike/matrix spike duplicate
oz = ounce
SVOCs = semivolatile organic compounds
TAL = target analyte list

6.3.1 Sample Packaging

Samples will be packaged carefully to avoid breakage or contamination and will be shipped to the laboratory at proper temperatures. The following sample package requirements will be met:

- Sample bottle lids must never be mixed. All sample lids must stay with the original containers.
- The sample volume level may be marked by placing the edge of the label at the appropriate sample height or by using a grease pencil. This will help the laboratory determine whether any leakage occurred during shipment. The label should not cover any bottle preparation QA/QC lot numbers.
- All sample bottles will be placed in a plastic bag to minimize leakage in case a bottle breaks during shipment.
- The samples will be cooled by placing on ice in sealed plastic bags. Ice is not to be used as a substitute for packing materials.
- Any remaining space in the sample shipping container should be filled with inert packing material. Under no circumstances should material such as sawdust, newspaper, or sand be used.
- The custody record must be sealed in a plastic bag and placed in the shipping container. Custody seals must be affixed to the sample cooler.

6.3.2 Shipping Containers

The appropriate shipping container will be determined by U.S. Department of Transportation (DOT) or International Air Transportation Association (IATA) regulations for the anticipated level of suspected contaminants. For the baseline monitoring field events, it is anticipated that all sample shipping containers will be commercially available coolers.

Shipping containers will be custody-sealed for shipment, as appropriate. The custody seals will be affixed so that access to the container can be gained only by breaking a seal.

Field personnel will arrange transportation of samples to the laboratory. When custody is relinquished to a shipper, field personnel will inform the laboratory sample custodian by telephone of the expected arrival time of the sample shipment and advise him or her of any time constraints on sample analysis.

Suggested guidelines for marking and labeling shipping containers are presented below. In all cases, DOT or IATA regulations will be consulted for appropriate marking and labeling requirements, which include the following:

- Use abbreviations only where specified.

- The words “This End Up” or “This Side Up” must be printed clearly on the top of the outer package. Upward-pointing arrows should be placed on the sides of the package.
- After a shipping container is sealed, two COC seals must be placed on the container, one on the front and one on the back. To protect the seals from accidental damage, clear strapping tape must be placed over them.

7 Decontamination and Management of Investigation-Derived Waste

7.1 Equipment Decontamination Procedures

Samples will be collected using either dedicated, disposable sampling equipment or non-dedicated equipment as indicated in Chapter 4. Procedures for decontaminating non-dedicated equipment are described below. Detailed information on decontamination procedures is provided in the applicable SOP.

Monitoring Well Development and Groundwater Sampling

Non-dedicated well development and sampling equipment (e.g., surge block, submersible pump, water level indicator) will be decontaminated between sampling locations using the following steps:

- Physical removal – Remove solid material using a dry brush or paper towels.
- Wash – Scrub with a solution of non-phosphate detergent (e.g., Alconox®) and tap water. A 5-gallon bucket lined with a clean garbage bag or a 3-foot long by 4-inch diameter polyvinylchloride (PVC) pipe will be filled with non-phosphate detergent and tap water. Materials and equipment will be scrubbed with a brush in the solution. The detergent solution will be flushed through the submersible pump.
- Deionized water rinse – A 3-foot-long by 4-inch diameter PVC pipe will be filled with deionized water. Equipment will be rinsed by flushing with deionized water.
- Dry: Air dry materials and equipment prior to use.
- Decontamination solutions will be changed out between each sampling location to prevent cross contamination.

Surface Water Sampling

Dedicated, disposable sampling equipment will be used to collect all surface water samples.

7.2 Vehicle Decontamination Procedures

Vehicles will be used to facilitate completion of the field activities. During the baseline monitoring field events, vehicle use at the site will include vehicles (e.g., all-terrain vehicles) used to transport staff and equipment between Red Devil and the RDM site. It is not expected that the planned use of the vehicles will result in significant contamination of the vehicles. In the event that the vehicles are subjected to significant contamination, they will be decontaminated by scrubbing with a brush and will be rinsed with potable water.

7.3 Investigation-Derived Waste Management

Investigation-derived waste (IDW) that is expected to be generated during the baseline monitoring events includes the following:

- Used dedicated, disposable sampling equipment;
- Used personal protective equipment (PPE), including gloves and booties;
- Used paper towels;
- Equipment decontamination fluids;
- Monitoring well development water; and
- Monitoring well purge water.

In general, IDW will be managed in accordance with criteria established in the document, *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009), and guidelines outlined in EPA guidance, *Guide to Management of Investigation-Derived Wastes* (OSWER Publication 9345.3-03FS). IDW will he managed as further described below.

Used dedicated sampling equipment, PPE, and paper towels will be grossly decontaminated if there is visible evidence of contamination (soil), placed in sturdy plastic bags, and shipped offsite at the conclusion of the field activities and disposed of at a sanitary landfill in Anchorage. No IDW will be disposed of at Red Devil.

Monitoring Well Development and Groundwater Sampling

Well development and purge water generated will be disposed of onto the ground at the time of sampling. Disposal of this purge water will be conducted in the area of the well following completion of sampling by pouring slowly onto the ground surface in such a way that the water fully infiltrates into the ground without ponding and does not enter surface water. Disposal will also be conducted in such a way that it does not transport sediment to surface water. Based on existing RI and baseline groundwater monitoring data, the potential for comparatively high concentrations of arsenic (greater than the RCRA TCLP limit of 5 milligrams per liter) in these wells is low.

Dedicated disposable sampling equipment used to collect groundwater samples will include dedicated, disposable sample tubing. These materials and used PPE will be managed as described above.

Surface Water Sampling

Dedicated disposable sampling equipment used to collect surface water samples will include dedicated, disposable sample tubing. These materials and used PPE will be managed as described above.

8 Station Positioning

A global positioning system (GPS) will be used to guide the sampling team to the surface water monitoring stations. The GPS receiver will be capable of surveying positions accurate to within 3 to 5 meters.

9 Deviations from the Field Sampling Plan

Deviations from the FSP are inevitable. Deviations may arise from changed field conditions, adjustment of sampling methods, inability to obtain samples from a planned location, and other circumstances. All deviations from the FSP will be carefully documented by the field team leader using the form presented in Figure 9-1. The nature and reason for FSP deviations will be documented in the RI report.

Red Devil Mine Baseline Monitoring
FSP Deviation Documentation

Date:	**Name:**
Description of Problem:	
Location of Problem:	
Description of Deviation to Address Problem:	
Other Means Considered but Rejected to Address Problem:	

Figure 9-1 FSP Deviation Documentation Form

10 References

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B Quality Assurance Project Plan

1001095.0002

FINAL
Quality Assurance Project Plan

Baseline Monitoring
Red Devil Mine, Alaska

June 2016

Prepared for:

United States Department of the Interior
Bureau of Land Management
Anchorage Field Office
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Table of Contents

Section **Page**

Table of Contents (cont.)

Section **Page**

List of Tables

Table **Page**

List of Abbreviations and Acronyms

%R	percent recovery
BLM	U.S Department of the Interior Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chain-of-custody
DQO	data quality objective
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HSO	Health and Safety Officer
ID	identifier
LCSs	laboratory control samples
LCSDs	laboratory control sample duplicates
MS/MSD	matrix spike/matrix spike duplicate
NCP	National Contingency Plan
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PM	Project Manager
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RDM	Red Devil Mine
RI	Remedial Investigation
RPD	relative percent difference
SHASP	Site-Specific health and safety plan
SOPs	standard operating procedures

1 Project Management and Objectives

The U.S. Department of the Interior Bureau of Land Management (BLM) plans to perform baseline monitoring of groundwater and surface water at the Red Devil Mine (RDM) site, located in a remote region of Alaska, approximately 250 air miles west of Anchorage. The RDM consists of an abandoned mercury mine and ore processing facility located on public lands managed by the U.S. Department of the Interior Bureau of Land Management (BLM) in southwest Alaska (see Work Plan Figure 1-1). The BLM initiated a Remedial Investigation (RI)/Feasibility Study (FS) at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority. An RI was performed by Ecology and Environment, Inc., (E & E) on behalf of the BLM under Delivery Order Number L09PD02160 and General Services Administration Contract Number GS-10F-0160J. The RI was performed following the Remedial Investigation/Feasibility Study Work Plan (E & E 2011). Results of the RI are presented in the Final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014). Results of the FS are presented in the Final Feasibility Study, Red Devil Mine, Alaska (E & E 2016a).

The purpose of the planned baseline monitoring is to further augment the RI results and identify temporal (e.g., seasonal and annual) trends in groundwater and surface water flow and contaminant concentrations and loading. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM.

Project scoping for the baseline monitoring includes the development of four plans: the project Work Plan, a Field Sampling Plan (FSP), and this document—a Quality Assurance Project Plan (QAPP), and a Site-Specific Health and Safety Plan (SHASP). The QAPP provides policies, procedures, specifications, standards, and documentation sufficient to produce data of quality adequate to meet project objectives and to minimize loss of data due to out-of-control conditions or malfunctions. The SHASP is to be completed by the BLM Contractor that will perform the baseline monitoring. The SHASP should specify employee training, protective equipment, medical surveillance requirements, and a contingency plan in accordance with 40 CFR 300.150 of the National Contingency Plan and 29 CFR 1910.120 1(1) and (1)(2).

This QAPP pertains to the environmental sampling and analysis program to be conducted at the RDM site. The purpose of this QAPP is to provide guidance so that all environmentally related data collection procedures and measurements are scientifically sound and of known, acceptable, and documented quality and to ensure that the sampling activities are conducted in accordance with the requirements of this project.

1.1 Project/Task Organization

The BLM's Project Manager (PM) will oversee the project and will be the primary contact for all project activities. Contact information for this and other key project roles is provided in Table 1-1. Roles and responsibilities of individual team members are described in the sections that follow.

Table 1-1 Contact Information

Organization	Contact	Title	Telephone	Address
BLM	Mike McCrum	PM	(907) 271-4426	Anchorage Field Office 4700 BLM Road Anchorage, Alaska 99507
BLM Contractor (TBD)	TBD	PM (TBD) QA (TBD) HSO (TBD)	TBD	TBD
Subcontracted Laboratory (TBD)	TBD	TBD	TBD	TBD

Key:
BLM = Bureau of Land management
HSO = Health and Safety Officer
PM = Project Manager
QA = quality assurance
TBD = to be determined

1.1.1 BLM Project Manager

The BLM PM for the RDM RI/FS is Mr. Mike McCrum. Mr. McCrum has overall responsibility for the project, including sampling activities at the site.

As the PM, Mr. McCrum is responsible for:

- Defining project objectives.
- Establishing project policies and procedures to address the specific needs of the overall project and of each task.
- Granting final approval of project plans and reports generated by contractors.
- Ensuring that plans are implemented according to schedule.

- Committing the available resources necessary to meet project objectives and requirements.
- Evaluating project staffing requirements and contractor resources as needed to ensure performance within budget and schedule constraints.
- Informing contractor personnel of any unanticipated client requests or needs.
- Providing site access (if necessary).
- Reviewing work progress for each task to ensure that budgets and schedules are met.
- Reviewing and analyzing overall performance with respect to goals and objectives.
- Implementing corrective actions resulting from staff observations, quality assurance (QA)/quality control (QC) surveillance, and/or QA audits.
- Reviewing and approving project-specific plans.
- Directing the overall project QA program.
- Maintaining QA oversight of the project.
- Reviewing QA sections in project reports as applicable.
- Reviewing QA/QC procedures applicable to this project.
- Initiating, reviewing, and following up on response actions, as necessary.
- Arranging performance audits of measurement activities, as necessary.

1.1.2 Contractor Project Manager

The Contractor PM is responsible for the overall management and coordination of the Contractor's implementation of the baseline monitoring project, including collection of water and any other additional samples from the RDM area. The PM will have overall responsibility for performing all appropriate procedures for sample collection. The Contractor PM will be responsible for:

- Maintaining communications with the BLM regarding the site work.
- Assembling and supervising the project team.
- Producing and reviewing deliverables, including work plans and reports.
- Tracking work progress against planned budgets and schedules.
- Scheduling personnel and material resources.
- Implementing all aspects of the Work Plan and applicable guidance documents, including this QAPP and other project documents.
- Notifying the BLM of the fieldwork activities.
- Gathering sampling equipment and field logbook(s).

- Maintaining communication with the analytical laboratory about the sampling schedule, delivery orders, and sample analysis.
- Maintaining communication with the analytical laboratory about receipt of analytical results.
- Ensuring that the quantity and location of all samples meet the requirements of appropriate work plans.
- Identifying problems, resolving difficulties in consultation with QA staff, and implementing and documenting corrective action procedures.
- Maintaining proper chain-of-custody (COC) forms during sampling events.
- Overall implementation of the baseline monitoring.

1.1.3 Contractor Quality Assurance Manager

The Contractor QA Manager will:

- Assist the Contractor PM in completing the data quality objective (DQO) selection process to ensure that project objectives are met.
- Provide oversight of the review and approval by the project chemist of the use of laboratory data.
- Direct the data validation activities and provide oversight for the preparation of data usability reports.
- Identify the need for corrective actions and solutions to laboratory QC problems or nonconformance with QAPP criteria.
- Provide appropriate direction and support to field sampling staff.

The Contractor QA Manager will also be responsible and accountable for selected project activities involving laboratory analyses, usability of analytical laboratory results, and data reports. As appropriate, the Contractor QA Manager will:

- Review and evaluate analytical data quality.
- Perform or direct data validation activities and prepare data usability reports.
- Identify the need for corrective actions and solutions for laboratory QC problems or nonconformance.
- Inform the Contractor PM of QA or QC deficiencies and work in cooperation to resolve program issues.
- Help prepare QA/QC reports as requested by the Contractor PM.

1.1.4 Contractor Field Sampling Team

Field staff personnel are responsible for collecting samples under the direction of the Contractor PM. This includes:

- Scheduling sampling activities and notifying the laboratory of sample delivery schedules.
- Gathering the necessary sampling supplies, equipment, containers, preservatives, and forms.
- Collecting samples in accordance with the FSP and applicable standard operating procedures (SOPs).
- Ensuring that the quantity and location of all samples meet the requirements of appropriate work plans.
- Measuring and recording required field screening data.
- Documenting sampling activities such as completion of data collection forms, labeling of samples, and preparation of COC forms.
- Maintaining proper COC forms during sampling events and delivery of the samples to the laboratory.
- Reporting any problems encountered in the course of sampling to the RI Lead.

1.1.5 Contractor Project Health and Safety Officer

The project Health and Safety Officer (HSO) will review the project SHASP for the field crew to follow during all field activities. A site HSO will be responsible for ensuring that project personnel adhere to the site-specific SHASP during sampling activities. This officer will report to the Contractor PM. As appropriate, the project and site HSOs will:

- Evaluate safety plans and other submittals from subcontractors.
- Provide project health and safety orientation and training for project staff and subcontractors.
- Verify and maintain medical and safety training documentation.
- Inspect work areas for hazards.
- Evaluate appropriate personal protective equipment and decontamination zone delineation.
- Conduct safety monitoring, as needed.
- Report and follow up on incident reports.

1.1.6 Contract Laboratories

Sampling activities for the RDM baseline monitoring project will be implemented by the Contractor under contract with the BLM.

Analytical services for the RDM baseline monitoring project will be provided by BLM-approved laboratories that have entered into a subcontract agreement with the Contractor. More than one contract laboratory may be responsible for analyzing samples for this project. Water samples will be taken during fieldwork and sent via COC protocol to professional laboratories that are licensed to perform the specific analyses requested.

The contracted laboratory will be responsible for laboratory and related QA/QC issues and maintaining continual analytical service. Additional responsibilities will include:

- Scheduling laboratory personnel and material resources.
- Maintaining proper COC protocol and performing designated analytical services.
- Preparing and delivering analytical reports to the Contractor PM.
- Identifying problems, resolving difficulties in consultation with QA staff, and implementing and documenting corrective action procedures.
- Maintaining QA/QC for the laboratory.

1.2 Problem Definition/Background

Detailed descriptions of the RDM history, previous investigations, and existing data quality are provided in the final RI report (E & E 2014) and the Draft 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2016b).

The RI included an investigation of groundwater and surface water, as a single sampling event. It did not include multi-event trend and variability information about the groundwater and surface water systems. The planned baseline monitoring is intended to further augment the RI results and identify temporal (e.g., seasonal and annual) trends in groundwater and surface water flow and contaminant concentrations and loading. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM.

1.3 Project Objectives and Related Sampling

The objective of the baseline monitoring is to augment the RI results and identify temporal (e.g., seasonal and annual) trends in groundwater and surface water flow and contaminant concentrations and loading. Contaminant concentration data also will be compared to remedial goals and remedial action objectives as they are developed by the BLM.

The planned baseline monitoring program is defined in the FSP (Appendix A of the Work Plan). The approach involves collection of surface water and groundwater from selected existing monitoring locations. Analysis of data collected from these sampling events will allow for evaluations of the spatial and temporal distribution of contaminants.

1.4 Data Measurement Objectives

The data measurement objectives provide a means for control and review of the project so that environmentally related measurements and data collected by the field sampling teams are of known and acceptable quality.

Every reasonable attempt will be made to obtain an acceptable and high-quality set of usable field measurements and analytical data. If a measurement cannot be obtained or is unusable for any reason, the effect of the missing or invalid data will be evaluated. Precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) are indicators of data quality. PARCCS goals are established to help assess data quality. The following paragraphs define PARCCS parameters associated with this project.

Precision

The precision of a measurement is an expression of mutual agreement among individual measurements of the same property taken under prescribed similar conditions. Precision is quantitative and most often expressed in terms of relative percent difference (RPD). Precision of the laboratory analysis will be assessed by comparing original and duplicate results. The RPD will be calculated for each pair of duplicate analyses using the following equation.

$$RPD = |S - D| \times 100 / ([S + D] / 2)$$

Where:
S = first sample value (original value)
D = second sample value (duplicate value)

Precision of reported results is a function of inherent field-related variability plus laboratory analytical variability, depending on the type of QC sample. Various measures of precision exist, depending upon “prescribed similar condition.” Field duplicate samples will be collected to provide a measure of the contribution of field-related sources to overall variability. Acceptable RPD limits for field duplicate measurements will be less than or equal to 20% for aqueous matrices and less than or equal to 50% for other matrices. Contribution of laboratory-related sources to overall variability is measured through various laboratory QC samples. Acceptable RPD limits for laboratory measurements are specified in the source methods. Precision limits for the analyses to be run for the RI/FS are presented in Table 1-2.

Accuracy

Accuracy is the degree of agreement of a measurement with an accepted reference or true value and is a measure of the bias in a system. Accuracy is quantitative and usually expressed as the percent recovery (%R) of a sample result. The %R is calculated as follows.

$$\%R = (SSR - SR / SA) \times 100$$

Where:
SSR = spiked sample result
SR = sample result
SA = spike added

Ideally, it is desirable for the reported concentration to equal the actual concentration present in the sample. Analytical data will be evaluated for accuracy. Matrix spikes (MSs) and/or laboratory control samples (LCSs)/laboratory control sample duplicates (LCSDs) will be used, whichever is applicable. Accuracy criteria are as follows (EPA 1990):

Inorganic MSs	=	75% –125% recovery
Organic MSs	=	60% –140% recovery
LCS/LCSDs	=	80% –120% recovery

Accuracy limits for the analyses to be run for RI/FS are included in Table 1-2.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the following:

- The characteristic being measured,
- Parameter variations at a sampling point, and
- An environmental condition.

Representativeness is a qualitative and quantitative parameter that is most concerned with the proper design of the sample plan and the absence of cross-contamination of samples. Acceptable representativeness will be achieved through:

1. Careful, informed selection of sampling locations;
2. Selection of testing parameters and methods that adequately define and characterize the extent of possible contamination and meet the required parameter reporting limits;
3. Proper gathering and handling of samples to avoid interferences and prevent contamination and loss; and
4. Use of uncontaminated sample containers as the sample collection tool, eliminating the need for decontamination of sampling equipment and possible cross-contamination of samples.

Representativeness is a consideration that will be employed during all sample location and collection efforts. The representativeness will be assessed qualitatively by reviewing the procedures and design of the sampling event and quantitatively by reviewing the laboratory blank samples. If an analyte is detected in a field or laboratory blank, any associated positive result less than five times the detected concentration of the blank may be considered undetected.

Completeness

Completeness is a measure of the amount of usable data obtained from a measurement system compared with the amount that was expected to be obtained under correct normal conditions. Usability will be determined by evaluation of the PARCCS parameters, excluding completeness. Data that are reviewed and need no qualification or are qualified as estimated or undetected are considered usable. Rejected data are not considered usable. Completeness will be calculated following data evaluation. Completeness is calculated using the following equation:

$$\% \text{ Completeness} = (DO/DP) \times 100$$

Where:
DO = data obtained and usable
DP = data planned to be obtained

A completeness goal of 90% is projected for the data set collected for this investigation. This goal will be assessed for the project as a whole, as well as for individual parameters and study areas within the RDM site. If the completeness goal is not met, additional sampling may be necessary to adequately achieve project objectives.

Comparability

Comparability is a qualitative parameter. Consistency in the acquisition, handling, and analysis of samples is necessary for comparison of results. Data developed under this investigation will be collected and analyzed using standard U.S. Environmental Protection Agency (EPA) analytical methods and QC procedures to ensure comparability of results with other analyses performed in a similar manner. Data resulting from this field investigation may subsequently be compared with other data sets.

Comparability of the data collected at the RDM site will be achieved by following, to the extent possible, the same SOPs for sample collection and analysis.

Sensitivity

Sensitivity is the achievement of method detection limits and depends on instrument sensitivity and sample matrix effects. Therefore, it is important to monitor the sensitivity of data-gathering instruments to ensure that data quality is met through constant instrument performance. For this project, adequate sensitivity was ensured by selection of methods with method detection limits and practical quantitation limits below the potential the applicable or relevant and appropriate requirements. These requirements are outlined in detail in Section 6 of the RI/FS Work Plan. Required detection limits are presented in Table 1-2 at the end of this chapter.

Analytical methods for chemical analysis of solid waste, water, and other wastes will follow EPA-defined testing methods and protocols (EPA 1980, 1983). The specific EPA analytical methods for chemical analyses that have been selected for this project are also given in Table 1-2.

1.5 Special Training and Certifications

The Contractor will ensure that qualified, experienced, and trained staff perform or oversee all data collection and sampling tasks conducted under the Contractor's direction. The field staff, including subcontractors that perform work on the site, will have completed training that meets the requirements of 29 Code of Federal Regulations (CFR) 1910.120 (Hazardous Waste Operations and Emergency Response), including up-to-date annual refresher training. Documentation and skills certification will be completed as described in 29 CFR 1910.120 and will be available for inspection upon request. Additional information is provided in the SHASP to be completed by the BLM Contractor performing the baseline monitoring.

1.6 Documents and Records

This section summarizes the documents and records to be generated for the RDM baseline monitoring project.

1.6.1 Planning Documents

The following planning documents have been prepared or are anticipated for this project:

- FSP (Appendix A of the Work Plan) – Defines sampling and data collection methods that will be used for the project. Includes sampling objectives, sample locations and frequency, sampling equipment and procedures, and sample handling and analysis. Documents procedures that will be used to ensure that sample collection activities are conducted in accordance with technically acceptable protocols and that data collected in the field meet the DQOs established during the scoping.
- QAPP (Appendix B of the Work Plan) – This QAPP has been prepared to describe the project objectives and organization, functional activities, and QA/QC protocols that will be used to achieve the desired DQOs.
- SHASP – The SHASP specifies employee training, protective equipment, medical surveillance requirements, SOPs, and a contingency plan in accordance with 40 CFR 300.150 of the National Contingency Plan and 29 CFR 1910.120 1(1) and (1)(2). The SHASP is to be completed by the BLM Contractor that performs the baseline monitoring.

1.6.2 Reports

The reports that will be developed to document the results and identify potential future actions are described below.

Data collected during baseline monitoring will be reduced and tabulated for analysis. The data will be validated with respect to requirements outlined in the site-specific FSP and this QAPP. All usable data will be analyzed and mapped to determine whether the project objectives have been met. Any data gaps will be identified and discussed with the BLM PM. Any recommendations for additional work will be discussed during a meeting with the PM. If the baseline monitoring requirements have been met, a baseline monitoring report will be prepared.

Baseline Monitoring Reports

The Contractor will validate all analytical data collected during monitoring events and prepare QA data reports. The validated data will be presented in tabular format, supplemented by maps and figures illustrating sample locations and trends of the contaminants of most interest. Separate data reports will be generated for each monitoring event. Hard copies and electronic deliverables of each report will be delivered as specified by the BLM.

Laboratory Reports

Each laboratory will submit its standard analytical data reports to the Contractor PM. The analytical laboratory deliverables will include the following:

- Case narrative (including any problems encountered, protocol modifications, and/or corrective actions taken);
- Sample analytical and QA/QC results with units;
- All protocols used during analyses;
- Any protocol deviations from the approved sampling plan;
- Surrogate recovery results;
- Matrix spike/matrix spike duplicate (MS/MSD) results;
- Laboratory duplicate/triplicate results;
- Blank results; and
- Sample custody records (including original COC forms).

Field Records

A record of samples, analyses, and field events will be kept in a field logbook. A complete record of all field activities will be maintained. Field documentation will include permanently bound field logbooks, field forms, digital photographs, COC documents, and sample identification labels.

Table 1-2 Analytes, Analytical Methods, and Screening Levels

Matrix	Groundwater/ Surface Water						
Analytical Group	**Analyte**	**Analytical Method**	**Units**	**Surface Water Chronic Water Quality Comparison Level(a)**	**Surface Water Chronic Water Quality Comparison Level Source**	**EPA Regional Screening Level(e)**	**State of Alaska Groundwater Cleanup Level(f)**
Inorganics, Total and Dissolved	Aluminum	EPA 6010B	µg/L	NA	NA	2000	NA
	Antimony	EPA 6020A (mass=121)	µg/L	30	Suter and Tsao (1996), Tier II SCV	0.78	6
		EPA 6020A (mass=123)	µg/L				
	Arsenic	EPA 6020A	µg/L	150	ADEC (2008a) and EPA (2009)	0.052	10
	Barium	EPA 6020A (mass=135)	µg/L	4	Suter and Tsao (1996), Tier II SCV	380	2000
		EPA 6020A (mass=137)	µg/L				
	Beryllium	EPA 6020A	µg/L	0.66	Suter and Tsao (1996), Tier II SCV	2.5	4
	Cadmium	EPA 6020A (mass=111)	µg/L	NA	NA	0.92	5
		EPA 6020A (mass=114)	µg/L				
	Calcium	EPA 6010B	µg/L	NA	NA	NA	NA
	Chromium	EPA 6020A (mass=52)	µg/L	67(b)	ADEC (2008a) and EPA (2009)	2200 (as Cr(III), Insoluble salts)	100
		EPA 6020A (mass=53)	µg/L				
	Cobalt	EPA 6020A	µg/L	23	Suter and Tsao (1996), Tier II SCV	0.6	NA
	Copper	EPA 6020A (mass=63)	µg/L	8.0(b)	ADEC (2008)	80	1000
		EPA 6020A (mass=65)	µg/L				
	Iron	EPA 6010B	µg/L	NA	NA	1400	NA
	Lead	EPA 6020A	µg/L	2.2(b)	ADEC (2008a) and EPA (2009)	15	15
	Magnesium	EPA 6010B	µg/L	NA	NA	NA	NA
	Manganese	EPA 6020A	µg/L	120	Suter and Tsao (1996), Tier II SCV	43	NA
	Mercury (low level)	EPA 1631	ng/L	770	ADEC (2008a) and EPA (2009)	63	2
	Mercury	EPA SW846 7470A	µg/L	0.77	ADEC (2008a) and EPA (2009)	0.063	0.002
	Nickel	EPA 6020A (mass=60)	µg/L	41(b)	ADEC (2008a) and EPA (2009)	39	100
		EPA 6020A (mass=62)	µg/L				
	Potassium	EPA 6010B	µg/L	NA	NA	NA	NA
	Selenium	EPA 6020A (mass=82)	µg/L	4.6(c)	ADEC (2008a) and EPA (2009)	10	50
		EPA 6020A (mass=78)	µg/L				
	Silver	EPA 6020A	µg/L	2.6(d)	ADEC (2008a) and EPA (2009)	9.4	100
	Sodium	EPA 6010B	µg/L	NA	NA	NA	NA
	Thallium	EPA 6020A	µg/L	NA	NA	0.02	2
	Vanadium	EPA 6020A	µg/L	20	Suter and Tsao (1996), Tier II SCV	8.6	260
	Zinc	EPA 6020A (mass=66)	µg/L	18(b)	ADEC (2008a)	600	5000
		EPA 6020A (mass=67)	µg/L				
		EPA 6020A (mass=68)	µg/L				
Semivolatile Organic Compounds	SVOCs	EPA 8270D	µg/L	Compound-specific	Suter and Tsao (1996).	Compound-specific. Per EPA (2015)	Compound-specific. Per 18 AAC 75.345 Table C
Petroleum	Gasoline Range Organics	AK 101	mg/L	NA	NA	NA	1.5
	Diesel Range Organics	AK 102	mg/L	NA	NA	NA	2.2
Volatile Organic Compounds	Benzene	EPA 8021B/8260	µg/L	NA	NA	0.46	5
	Toluene	EPA 8021B/8260	µg/L	NA	NA	110	1000
	Ethylbenzene	EPA 8021B/8260	µg/L	NA	NA	1.5	700
	m/p-Xylene	EPA 8021B/8260	µg/L	NA	NA	19	10,000 (total Xylenes)
	o-Xylene	EPA 8021B/8260	µg/L	NA	NA	19	10,000 (total Xylenes)
Conventionals	Sulfate	EPA 300.0	mg/L	NA	NA	NA	NA
	Chloride	EPA 300.0	mg/L	NA	NA	NA	NA
	Fluoride	EPA 300.0	mg/L	NA	NA	NA	NA
	Nitrogen, Nitrate-Nitrite	EPA 353.2	mg/L	NA	NA	NA	NA
	Carbonate, Bicarbonate	EPA 310.1	mg/L	NA	NA	NA	NA
	Total Dissolved Solids (TDS)	EPA 160.1 / SM 2540C	mg/L	NA	NA	NA	NA
	Total Suspended Solids (TSS)	EPA 160.2 / SM 2540D	mg/L	NA	NA	NA	NA
	Carbonate Alkalinity as CaCO3	SM 2320B	mg/L	NA	NA	NA	NA
	Bicarbonate Alkalinity as CaCO3	SM 2320B	mg/L	NA	NA	NA	NA
	Hydroxide Alkalinity as CaCO3	SM 2320B	mg/L	NA	NA	NA	NA
	Alkalinity	SM 2320B	mg/L	NA	NA	NA	NA
	Total Organic Carbon	SW846 Method 9060	mg/L	NA	NA	NA	NA

Key:

µg/L = micrograms per liter
mg/L = milligrams per liter
NA = Not applicable
ng/L = nanograms per liter
RSL = Regional Screening Level

Notes:

(a) = Surface water comparison criterion is for dissolved fraction.

(b) = Chronic hardness-adjusted criterion value was calculated using CCC = exp{mC [ln (hardness)]+ bC} (CF) and parameters specified in Appendix B - Appendix B-Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent (ADEC 2008a and EPA 2009). A total hardness value of 87.7 mg/L as CaCO3, based on the average value for Red Devil Creek surface water samples, is assumed.

(c) = The recommended water quality criterion for selenium of 5 µg/L is expressed in terms of total recoverable metal in the water column. The conversion factor (0.922-CCC) was used to convert this to a value that is expressed in terms of dissolved selenium.

(d) = No chronic criteria hardness adjustment parameters are available for silver. An acute hardness-adjusted criterion value calculated using CMC (dissolved) = exp{mA [ln(hardness)]+ bA} (CF) and parameters specified in Appendix B - Appendix B-Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent (ADEC 2008a and EPA 2009). A total hardness value of 87.7 mg/L as CaCO3, based on the average value for Red Devil Creek surface water samples, is assumed.

(e) = EPA (2015) Regional Screening Levels for Tap Water (levels at cancer risk 10^-6 and HQ = 1.0).

(f) = State of Alaska groundwater cleanup levels (18 AAC 75.345 Table C).

2 Data Generation and Acquisition

2.1 Sampling Design

The sampling design for the RDM site is summarized in Section 4 of the Work Plan and described in detail in the FSP, included as Appendix A of the Work Plan.

2.2 Sampling Methods

Sampling methods are described in detail in the FSP, included as Appendix A of the Work Plan.

2.3 Sample Handling and Custody

Sample handling and custody procedures are described in detail in the FSP, included as Appendix A of the Work Plan.

2.4 Analytical Methods

The specific EPA analytical methods for chemical analyses that have been selected for this project are summarized in Table 1-2. The analytical methods were selected to provide data of known quality to meet the project DQOs and to maintain consistency and comparability with data from the previous sampling events. Subcontracted laboratories must provide documentation of their ability to meet method detection limits and reporting limits that are below the screening values presented in Table 1-2.

2.5 Quality Control

2.5.1 Field Quality Control

QC samples collected in the field will include field duplicates, rinsate blanks, and MS/MSDs. Each type of QA/QC sample is briefly described below.

Field Duplicates

A field duplicate sample is a second sample collected at the same time and location as the original sample. Field duplicate samples are collected simultaneously (an extra volume of one sample, which is then homogenized and split into equal aliquots) or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Duplicate sample results are used to assess precision of the overall sample collection and analysis process. For surface water and groundwater, field duplicate samples will be collected at a minimum frequency of one field duplicate for every 10 regular samples for each matrix and sampling method and/or type of equipment used. A maximum RPD of 30% for waters and 50% for soil and sediment will be used for evaluation of field duplicate comparability.

Rinsate Blanks and Equipment Blanks

Rinsate blanks are used to assess the effectiveness of equipment decontamination procedures when non-dedicated sampling equipment is used. A rinsate blank is a sample of American Society for Testing and Materials Type II reagent grade water or equivalent (i.e., deionized), poured into or over the sampling device or pumped through it, collected in a sample container, and transported to the laboratory for analysis. Rinsate blanks will be collected immediately after the equipment has been decontaminated. The blank will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. A minimum frequency of one rinsate blank per 20 field samples is required for each collection/decontamination method, by matrix and by sample type.

Equipment blanks are used to demonstrate that dedicated sampling equipment is adequately clean if a certificate is not available to demonstrate cleanliness. Equipment blanks will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. One equipment blank sample for dedicated equipment will be collected at a rate of one for each set of dedicated equipment (i.e., bailers and sample tubing) of identical manufacturer’s lot number.

Analyte concentrations in rinsate and equipment blanks must be below the applicable laboratory reporting limits. For common laboratory contaminants, the blank results may be up to five times the reporting limit.

Field Blanks

Field blanks are laboratory-provided, mercury-free water samples that are processed and treated as a regular sample in all respects, including contact with sampling devices, equipment, sampling site conditions, and analytical procedures. Field blanks are the best way to estimate how much mercury detected in a sample is from the site or can be attributed to contamination. Field blanks will be collected at a rate of one field blank for every 10 regular samples to be analyzed for low-level mercury.

Matrix Spikes/Matrix Spike Duplicates

MSs are used to assess the effect of the sample matrix on analyte recovery. An MS consists of an aliquot of a field sample to which the laboratory adds a known concentration of the analyte(s) of interest. An unspiked aliquot is also analyzed, and the %R for the spiked sample is calculated. Analysis of MSs requires collection of a sufficient volume of sample to accommodate the number of aliquots to be analyzed. The sample(s) chosen for MSs should be representative of the sample matrix but should not contain excessive concentrations of analytes or interfering substances. MSs are analyzed at a frequency of one MS per 20 or fewer samples for each matrix and each sampling event. Control limits for MSs are provided in the source methods and in the laboratory QA manuals.

2.5.2 Laboratory Quality Control

QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of glassware and reagents. Each type of laboratory-based QC sample will be analyzed at a rate of 5% or one per batch (a batch is a group of up to 20 samples analyzed together), whichever is more frequent.

Method Blank

A method blank is a sample generated in the laboratory consisting of an analyte-free matrix (e.g., reagent water) that is taken through the entire sample preparation and analysis with the field samples. It is used to monitor for contamination that may be introduced into the samples during processing within the laboratory. Evaluation criteria are provided in the source methods and in the laboratory QA manuals.

Laboratory Duplicate

A laboratory duplicate consists of an aliquot of a field sample that is taken from the same container as the initial field sample and prepared and analyzed with the field samples. The laboratory duplicate is used to monitor the precision (in terms of RPD) of the analytical process. In conjunction with field duplicates, the sampling precision can then be inferred. Criteria for laboratory duplicates are provided in the source methods and in the laboratory QA manuals.

Laboratory Control Sample

An LCS consists of a laboratory-generated sample that contains the analytes of interest at known concentrations. It may be prepared by the laboratory or purchased from an outside source. The LCS is taken through the same preparation and analytical procedures as the field samples. Analyte recoveries indicate the accuracy of the analytical system. LCSs and MSs together allow the overall accuracy of the sampling and analytical process to be determined. Criteria for LCS evaluation are provided in the source methods and in the laboratory QA manuals.

Additional Quality Control Samples

Certain analytical methods may require additional QC elements not described above. These may include surrogates, serial dilutions, and other elements. Specific requirements and evaluation criteria are provided in the source methods and laboratory QA manuals.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Field equipment will be maintained in accordance with manufacturers' instructions and the relevant field sampling SOPs.

All laboratory equipment will be maintained in accordance with the laboratory's SOPs.

2.7 Instrument/Equipment Calibration and Frequency

Field instruments will be calibrated immediately prior to use in accordance with manufacturers' instructions and the relevant field sampling SOPs. Calibrations will be verified periodically throughout each work day and at the end of the day. Records of field instrument calibrations will be kept in the field log books. Additional information is provided in the FSP.

Laboratory instruments will be calibrated in accordance with the source methods, laboratory SOPs, and laboratory QA manuals. In general, laboratory instrument calibration includes the following elements:

- Initial multi-point calibration to establish the working range of the instrument and response factors or calibration curve.
- Verification of proper calibration using a standard from an independent source.
- Ongoing calibration checks at a typical frequency of 10% throughout the analytical run and at the end of the run.
- Depending on the analytical method, additional calibration elements may be required including tuning checks, interference check samples, and internal standards.

Records of initial calibration, continuing calibration and verification, repair, and replacement will be filed and maintained by the laboratory. Calibration records will also be included in data reporting packages.

2.8 Inspection/Acceptance of Supplies and Consumables

Prior to acceptance, all supplies and consumables will be inspected by the Contractor sampling team or other contractors to ensure that they are in satisfactory condition and free of defects. Sample containers provided by the laboratory will be pre-cleaned to EPA specifications. Preservatives will be prepared from reagent-grade or higher chemicals. Calibration standards must be traceable to National Institute of Standards and Technology or another recognized source.

2.9 Non-direct Measurements

Non-direct measurements and data that will be collected for this project include the following:

- Sampling, analytical, and other data obtained from previous studies
- Global positioning system (GPS) survey of sample locations

Where possible and appropriate, these data will be obtained from peer-reviewed literature or other reputable sources such as university libraries, state and federal agencies, and the U.S. Geological Survey. The PM and/or QA Manager will review all data for consistency and accuracy. Where necessary, information will be verified by ground truthing or consultation with independent sources.

Maps and associated geographic information system (GIS) data will be continually improved as new information is obtained. Geographic coordinates will be collected for all new sample locations and included in the GIS project. All GPS data will be differentially corrected if needed. Data management discussed in Section 2.10 provides details about recording site data and incorporating these data into the project database and GIS.

2.10 Data Management

Daily field records constitute the primary documentation for field activities. Daily records are created using a combination of field logbooks and field data sheets. Field observations will be entered in field logbooks with enough detail to allow participants to accurately and objectively reconstruct events at a later time if necessary. Field logbooks will also document any deviations from the project scope, field protocols, or personal protection levels, as well as any changes in personnel. In all cases, deviations will be approved by the Contractor PM and, where necessary, the BLM PM, prior to implementation in the field.

Logbooks will be bound with consecutively numbered pages; logbook pages cannot be removed, even if they are partially mutilated. Entries will be made in indelible ink using the time of day (24-hour clock) as entry headers. All logbooks will be returned to the project file at the end of the field tasks.

Each laboratory will provide the analytical results as electronic data deliverable and as paper reports. Following guidelines in the *Environmental Laboratory Data and Quality Assurance Requirements* (ADEC 2009) and following the Laboratory Data Review Checklist (ADEC 2010), all paper laboratory reports provided to the Contractor will be checked to verify they incorporate the following information:

- A report narrative discussing any out-of-control events, corrective actions, deviations from SOPs, and other observations pertaining to the analytical process.
- A cross-reference of field sample identifiers (IDs) to laboratory sample IDs.
- Dates of collection, receipt at laboratory, preparation, and analysis.

- Data results for each sample with associated dilution factors and reporting limits.
- Results for all laboratory QC samples (LCS, MS, MSD, duplicates), including acceptance limits.
- Surrogate recoveries and acceptance limits for each sample.
- A copy of the sample login checklist documenting sample condition, cooler temperatures, and other characteristics as appropriate.
- A copy of the completed COC form signed by the laboratory.
- The raw data package, including initial and continuing calibration data, instrument performance checks, instrument run logs, and sample and blank data.

Each laboratory will maintain all original records relating to the analysis of the samples. These records will be maintained in such a way as to allow for complete reconstruction of the reported results by an independent party. These records will be available to the Contractor and/or the BLM upon request. The laboratory data reports will be maintained by the Contractor.

3 Assessment and Oversight

Assessments and oversight reports are necessary to ensure that procedures are followed as required and that deviations from procedures are documented. These reports also address activities for assessing the effectiveness of the implementation of the project and associated QA and QC activities. They also keep management and the client current on field activities.

3.1 Assessments and Response Actions

3.1.1 Assessments

The Contractor PM is responsible for overall quality and performance on this project; responsibilities include review of project activities to ensure that objectives are met on a day-to-day basis and that this QAPP and other project planning documents have been properly implemented. The Contractor QA Manager will also assist in this capacity.

The BLM is responsible for overseeing the QC aspects of each of its contractors. The BLM or its representative is responsible for the overall QC assessment of the project and may perform system audits at any time.

3.1.2 Response Actions

Response actions will be implemented on a case-by-case basis to correct quality problems. All personnel involved in the project are responsible for discovering QA problems or deficiencies in their areas of responsibility. Any such deficiencies must be reported immediately to the PM. As soon as possible after discovery, the PM will also propose resolution action in cooperation with personnel in the area where the deficiency was found. The corrective action process has two components that must be addressed: the resolution of the immediate problem and the prevention of future occurrences of the problem. It is the responsibility of the PM to ensure that both components are addressed and to finalize the action necessary to achieve resolution.

Results of the following QA activities may also initiate corrective actions:

- Performance audits,
- Systems audits, and

- Failure to adhere to the approved QAPP or project work plan.

3.2 Reports to Management

Field teams will note any quality problems in the applicable logbook or other form of documentation. QA reports to the PM will be provided whenever quality problems are encountered.

The laboratory is responsible for providing a summary of quality issues to the PM with each data report.

Data validation reports will be provided to the Contractor PM by the Contractor data validation specialist. These reports will include a discussion of any significant quality problems that were observed and their effect on the use of the data.

Quality issues identified by the field team, laboratory, and data validation specialist will be incorporated into the data evaluation report(s) submitted to the BLM. If significant problems are encountered, the PM will report these issues, along with the results of the necessary response actions, to the BLM in a separate memorandum.

4 Data Validation and Usability

4.1 Data Review, Verification, and Validation

Each member of the field team will be responsible for reviewing his or her work for completeness and accuracy. The Contractor PM will conduct an independent review of the field data to ensure that it meets the requirements of this QAPP and the FSP.

The subcontracted laboratory will be responsible for internal review of the data prior to issuance of reports. These review procedures are documented in the laboratory QA manuals.

Laboratory data packages will be reviewed by the QA Manager for completeness, compliance with project objectives, and fulfillment of the Laboratory Data Review Checklist (ADEC 2010).

4.2 Verification and Validation Methods

The analytical results will be validated by an experienced Contractor chemist. The data will be validated in accordance with the *National Functional Guidelines for Inorganic Data Review* (EPA 2010), *National Functional Guidelines for Organic Data Review* (EPA 2008), and *Guidelines for Data Reporting, Data Reduction, and Treatment of Non-Detect Values* (ADEC 2008b) in conjunction with the QA/QC requirements specified in each specific analytical method and any project-specific QC defined in the QAPP.

Analytical data will be validated against criteria for:

- Holding times and sample integrity,
- Instrument performance checks,
- Initial and continuing calibrations,
- Blank analyses,
- Laboratory QC compounds and standards,
- Field duplicates analyses,
- Organic internal standard and surrogate performance,
- Compound identification and compound quantification,

- Reported detection limits, and
- System performance and overall assessment of data.

Laboratory data will be assessed for usability in accordance with the DQOs presented in this QAPP. Results that are less than the reporting limit but that exceed the method detection limit will be qualified as estimates and used in calculations as a detected value. Both laboratory and field QA/QC data are also assessed for precision, accuracy, representation of true nature, comparability, and completeness.

Other data that may be reviewed for verification of total sample integrity include:

- Sample handling and storage,
- Field duplicates as identified to the reviewer,
- Sample preparation logs,
- Instrument standards (primary and secondary records), and
- Run logs for each instrument.

All corrections and/or notations will be added to the project database.

4.3 Reconciliation with User Requirements

Data validation reports prepared by the Contractor will include an evaluation of the usability of the data. PARCCS will be evaluated and compared with the project DQOs, in consultation with the QA Manager, as each data set is received. At the completion of the project, an overall assessment of data usability and compliance with project objectives will be conducted and documented in the Baseline Monitoring Report.

5 References

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